Draft Seven-Year Plan for the Development of JINR for 2024–2030

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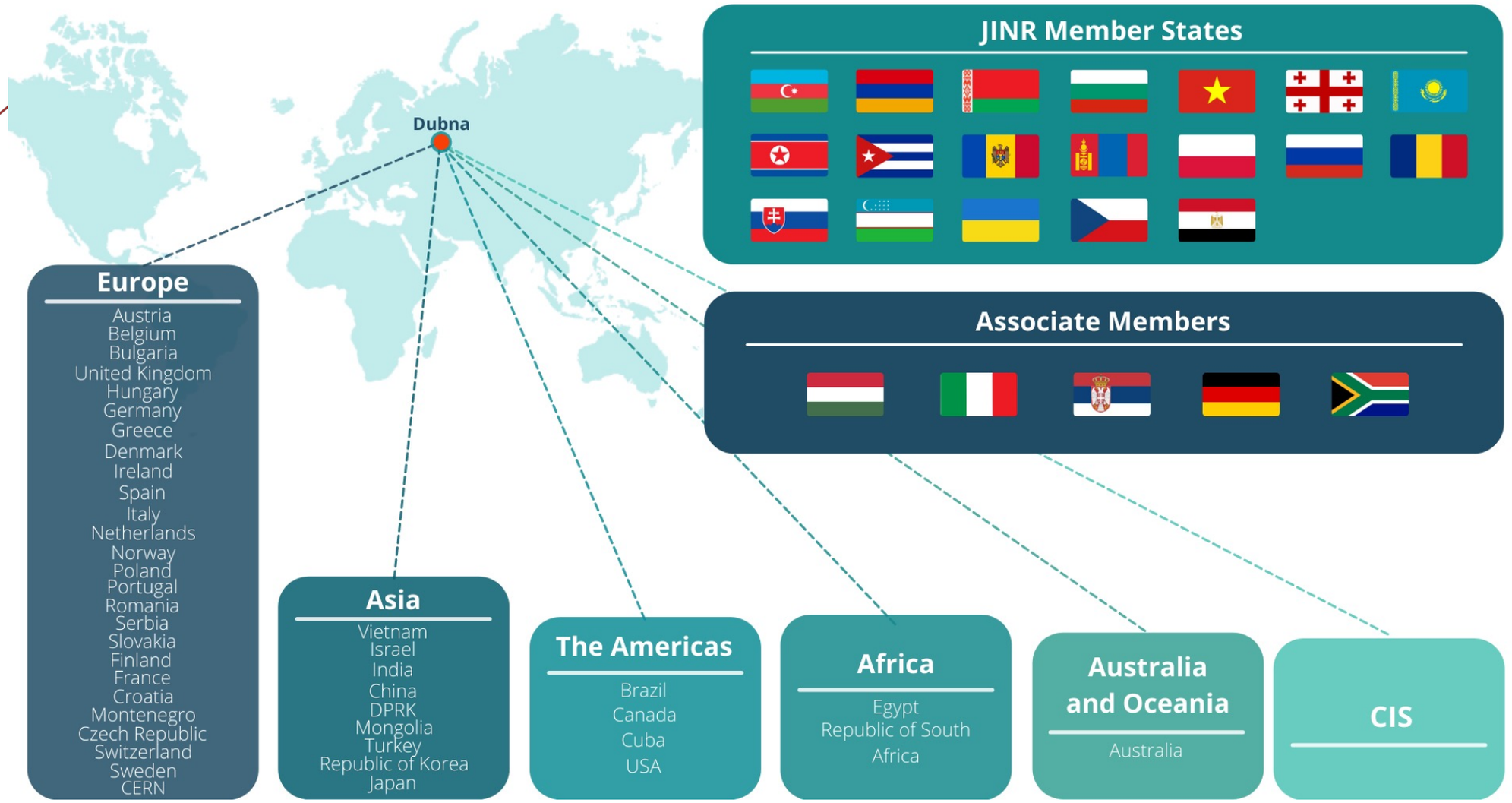
ОИЯИ на мировом научном глобусе

19 Стран-участниц
5 Асс.члены
900+ Партнероры

> 5100 чел
230 M$ бюджет

- Идея нейтринных осцилляций
- Антисигма-минус-гиперон
- Кумулятивный релятивистский эффект
- Открытие 11 новых элементов: 102-105,107,114-118.
- Ультрахолодные нейтроны
- Пострадиационная регенерация клеток
- Сверхтекучесть ядерной материи
- Цветовые заряды и правило кваркового счета
- Сверхнизкие температуры (мК)
- Гармоническое суперпространство в суперсимметрии

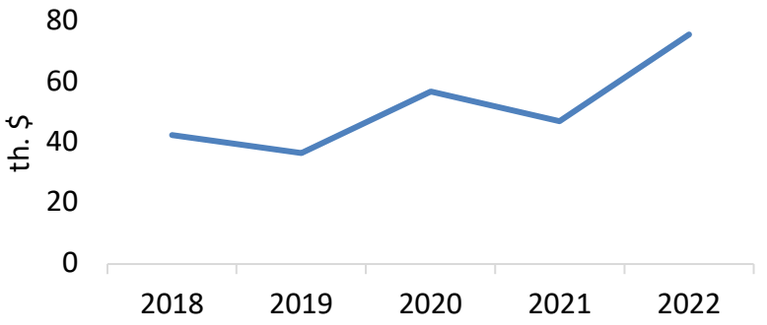
- Новое поколение импульсных реакторов
- СП ускоритель релятивистских ионов Нуклотрон
- Фабрика сверхтяжелых элементов ДС-280
- "Байкал" нейтринный гигатонный телескоп
- Коллайдер NICA
- Гиперконвергентный ИТ-кластер



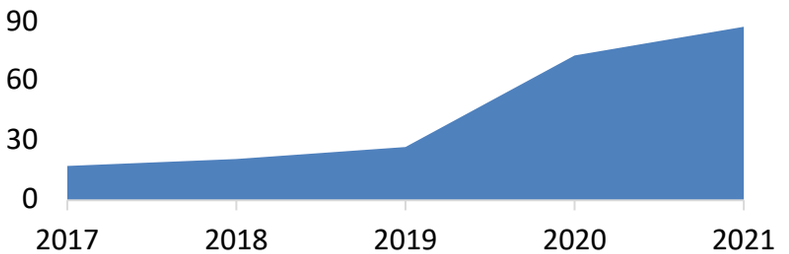
Высшим руководящим органом Института является Комитет полномочных представителей государств-членов. Научная политика ОИЯИ определяется Международным научным советом. Важным аспектом деятельности института является широкое международное научно-техническое сотрудничество. ОИЯИ поддерживает контакты более чем с 900 исследовательскими центрами и университетами в 64 странах мира. В России, крупнейшем партнере ОИЯИ, сотрудничество осуществляется со 150 научными центрами, университетами, промышленными предприятиями и фирмами из 50 городов.

RESEARCH CAPACITY-BUILDING

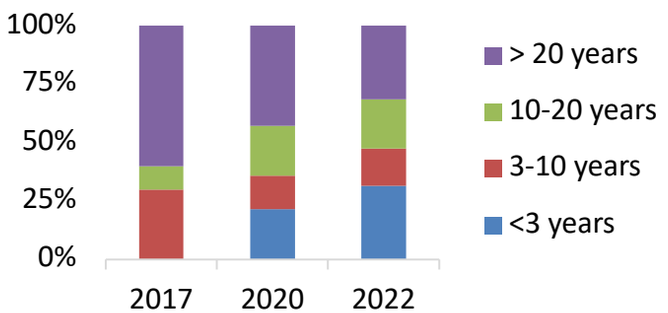
Cost of basic facilities and equipments per research scientist



Total amount of data in the JINR storage system (PB)

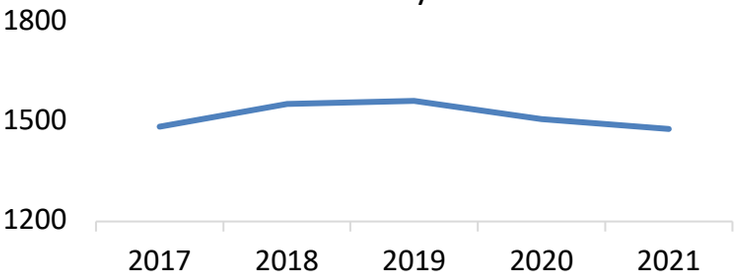


Breakdown of basic facilities by age



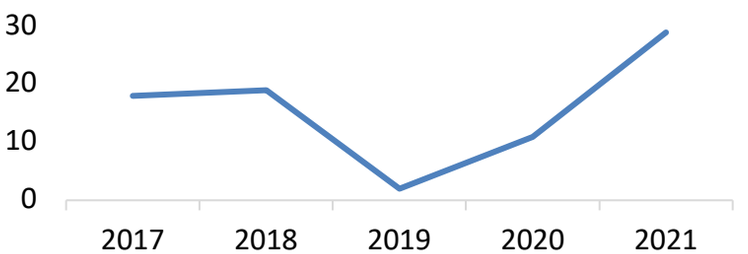
RESEARCH QUALITY AND EFFICIENCY

Total number of Results of Intellectual Activity

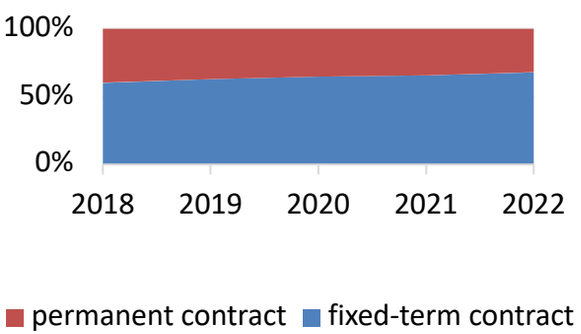


Results of Intellectual Activity (RIA) includes publications, defended dissertations and patents.

Number of dissertations defended by JINR staff



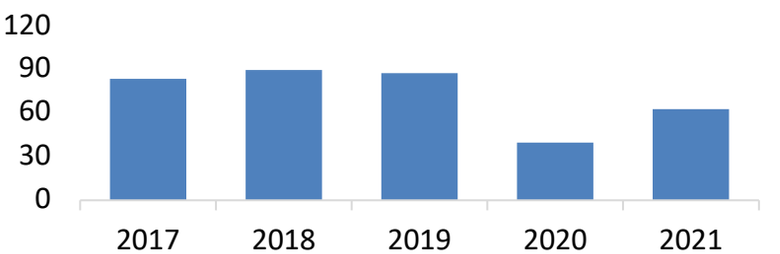
Distribution by contract type



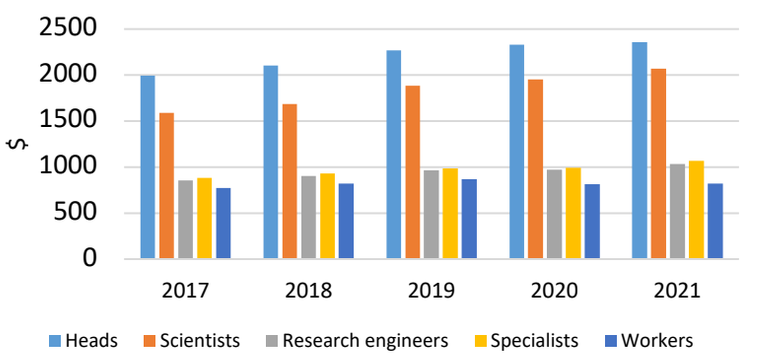
JINR AS AN INTERNATIONAL RESEARCH ORGANIZATION

	2020	2021	2022
Number of organizations in the partner network	931	1005	998
Number of JINR information centres	2	4	8
Number of collaborations	39	39	39

Number of meetings and conferences organized by JINR



Average monthly income by personnel categories



Воплощение 7-летней Программы развития ОИЯИ: 2016-2023

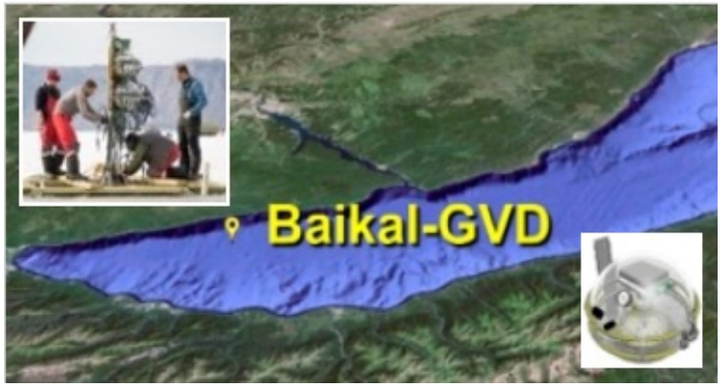
Основные научные направления

RHIP & Spin Physics (NICA complex)

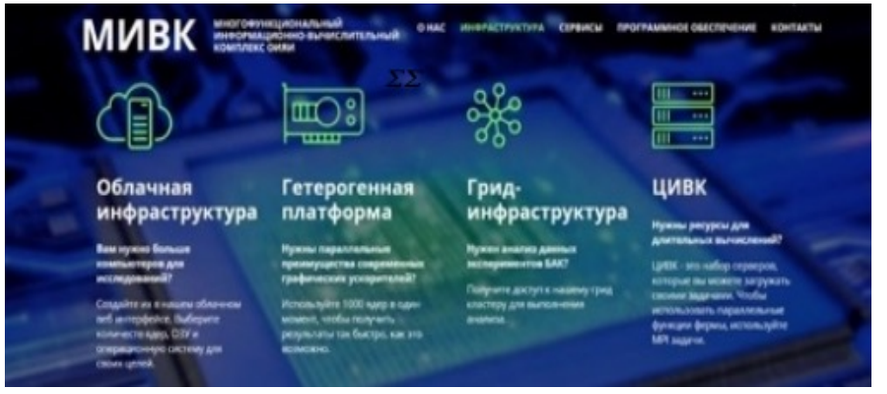
Low Energy Nuclear Physics (SHEF& DRIBS-III project

Condensed matter and Neutron physics (IBR-2M+spectrometers)

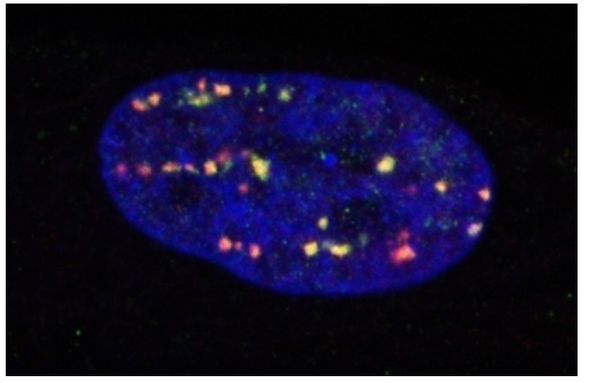
ν & Astroparticle physics (Baikal-GVD)



IT and HPC (MICC)

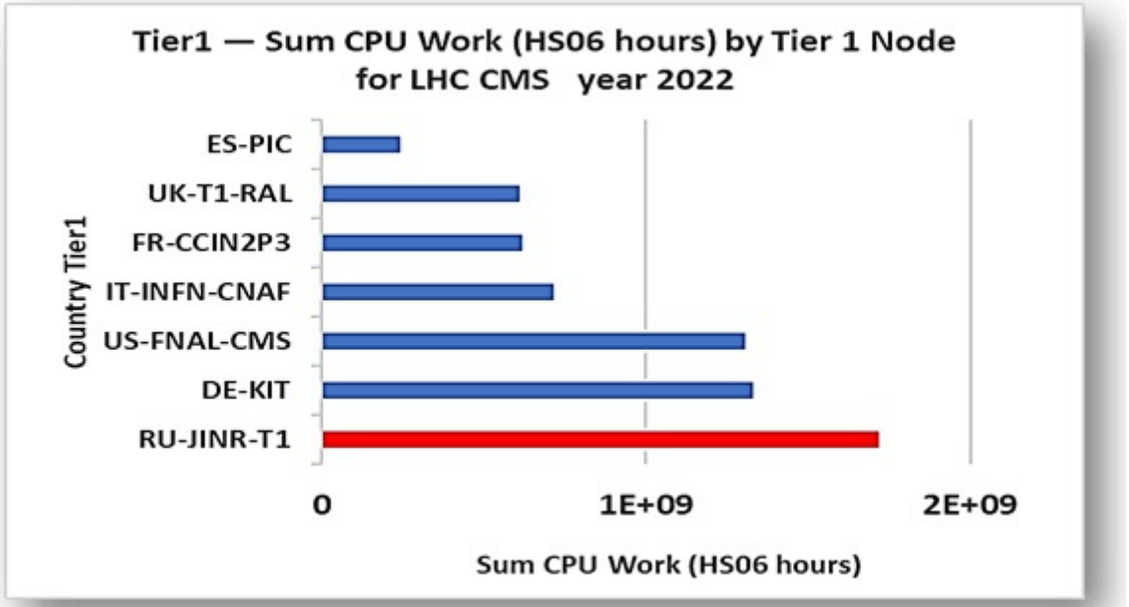


Life Sciences (RB, AB, BM)



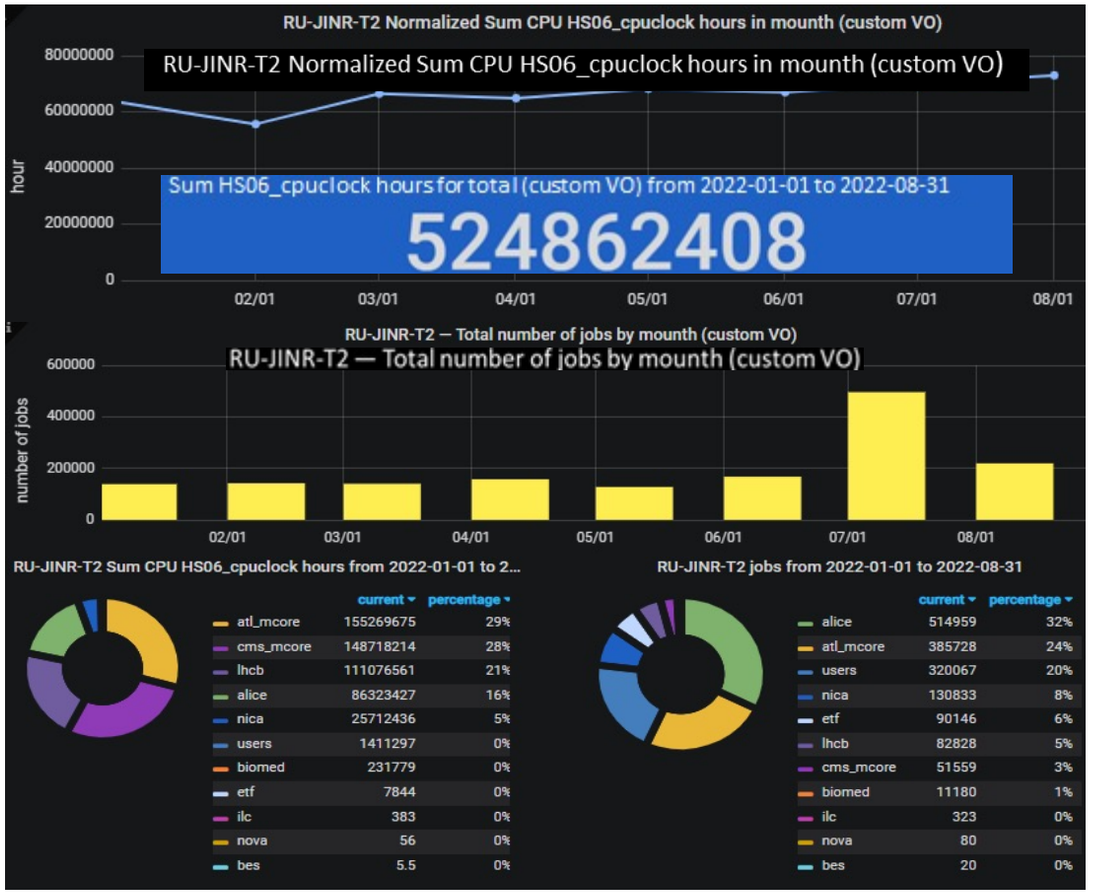
MICC – Grid infrastructure – Tier1 and Tier2

The JINR Tier1 center has demonstrated stable work not only for CMS (LHC), but also for MPD (NICA).
The Tier1 site for CMS is ranked first among world centers for CMS.

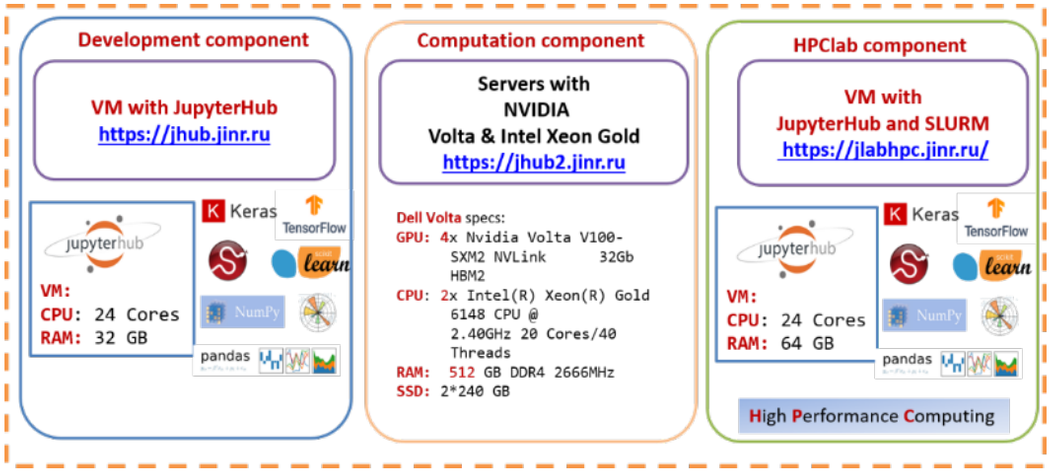


30% of all jobs executed at Tier1 JINR are NICA MPD jobs.

This year, a new accounting system for the MICC was put into operation at litmon.jinr.ru
524 862 408 HS06 hours were used at Tier2 for 1 587 723 jobs from NICA, LHC, ILC, NOvA, BIOMED and local users from 2022-01-01 to 2022-08-31.



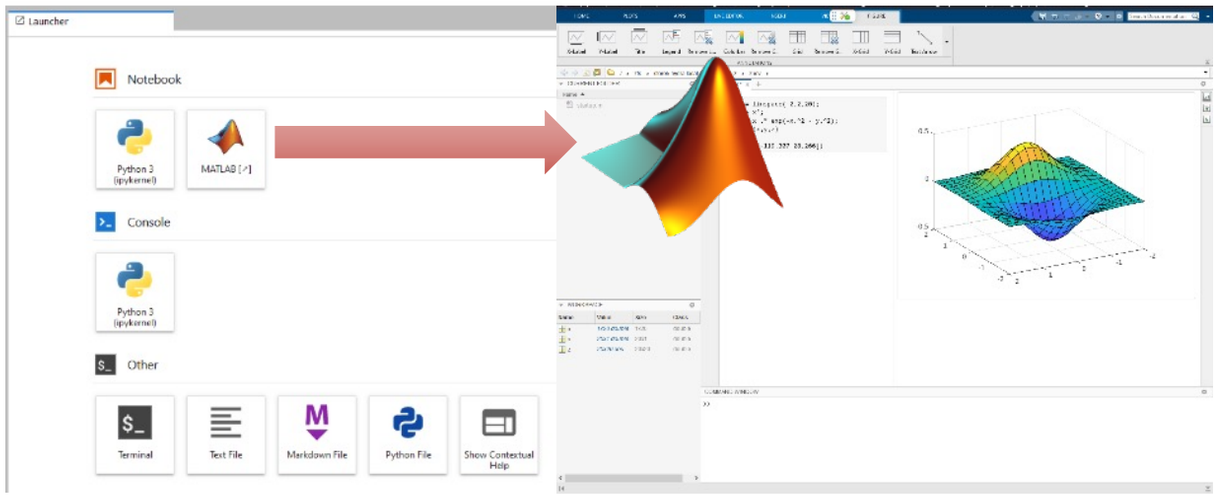
ML/DL/HPC Ecosystem of the HybriLIT Heterogeneous Platform: New Opportunities for Applied Research



The **ML/DL/HPC ecosystem** is now actively used **for machine and deep learning tasks.** At the same time, the accumulated tools and libraries **can be more widely used for scientific research**, including:

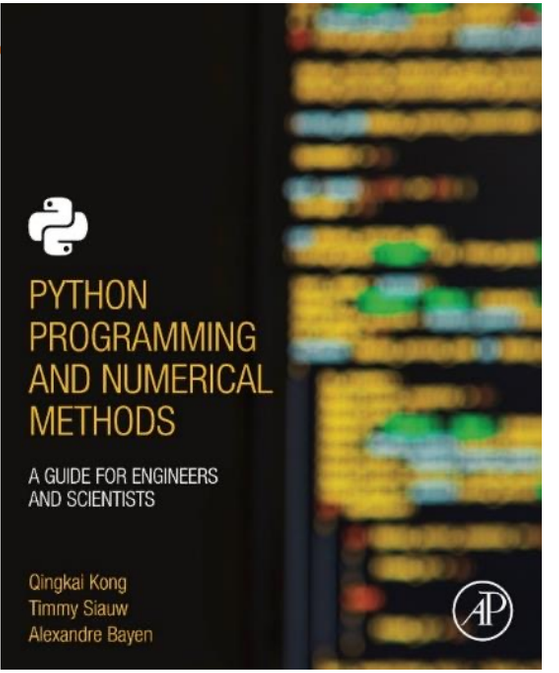
- numerical computations;
- parallel computing on CPUs and GPUs;
- visualization of results;
- accompanying them with the necessary formulas and explanations.

In 2022, on the ML/DL/HPC ecosystem, it became possible **to run the MATLAB code in Jupyter Notebook**, which allows one to effectively perform applied and scientific computations.



Parallel computations with Joblib

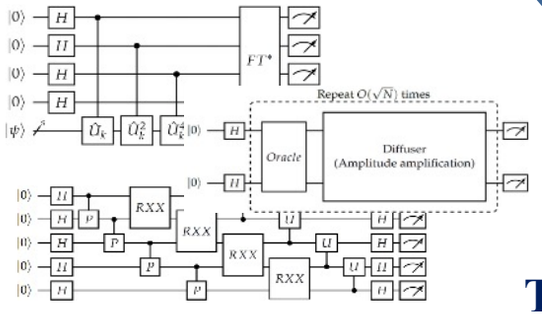
Python Numerical Methods



Quantum computing and quantum algorithms

Objective: development of quantum algorithms (QAs) to calculate complex atomic and molecular systems, taking into account the limiting capabilities of available computing resources.

Quantum algorithms



Quantum simulators

Qiskit
QuEST
qsim
CUQUANTUM

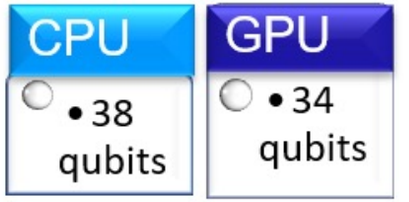
SC "Govorun"

TASKS

- Form a list of QAs required to solve tasks within the studied physical models
- Select the type of quantum simulator to simulate a classical architecture on computers
- Define resources for the selected quantum-limiting capabilities of available computing simulators (number of qubits and computation time)
- Search for exact solutions to urgent problems of quantum chemistry and study the chemical properties of heavy elements

Current result

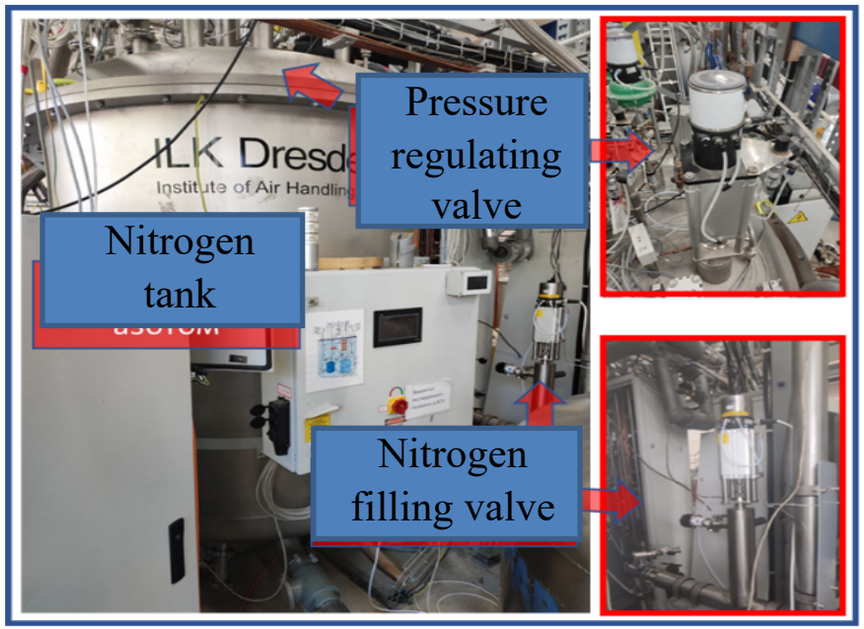
The limiting computing capacities of the "Govorun" supercomputer are revealed on the example of simulating quantum algorithms (quantum Fourier transform, quantum phase estimation, Grover's algorithm, test synthetic algorithm) using a different class of quantum circuits for the following simulators: QuEST, Qiskit, CuQuantum.

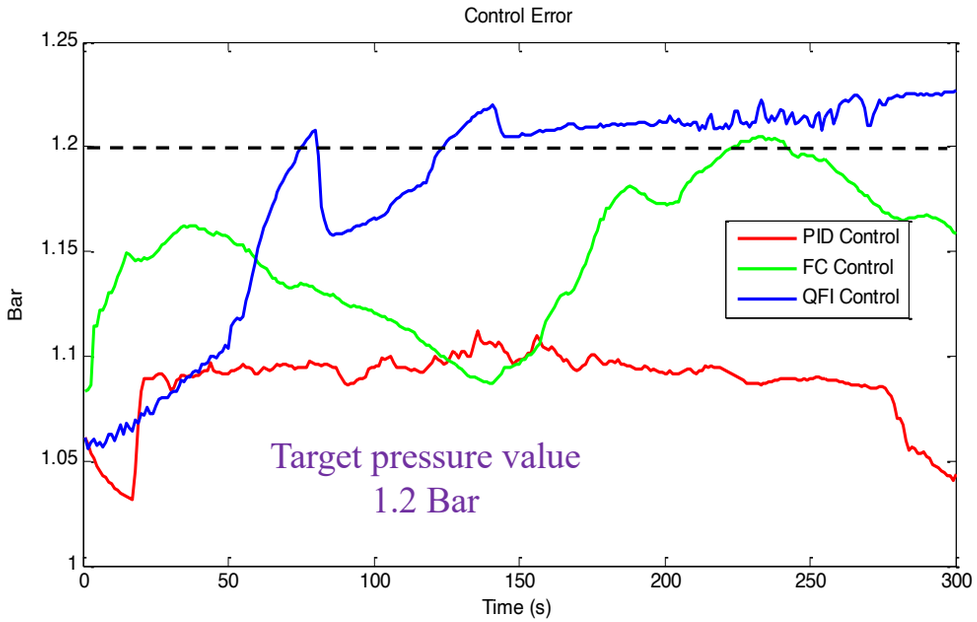


According to modern concepts, from 30 to 50 qubits are sufficient for the exact solution of most practically significant problems of quantum chemistry.

Quantum intelligent control

Tests of an **intelligent automatic control system for the nitrogen collector** of the satellite helium refrigerator #1 at the site of the cryogenic testing of superconducting magnets at VBLHEP **on the basis of quantum algorithms** (QFI) are successfully completed.





Control of the process of reaching a predetermined pressure level in cooling mode

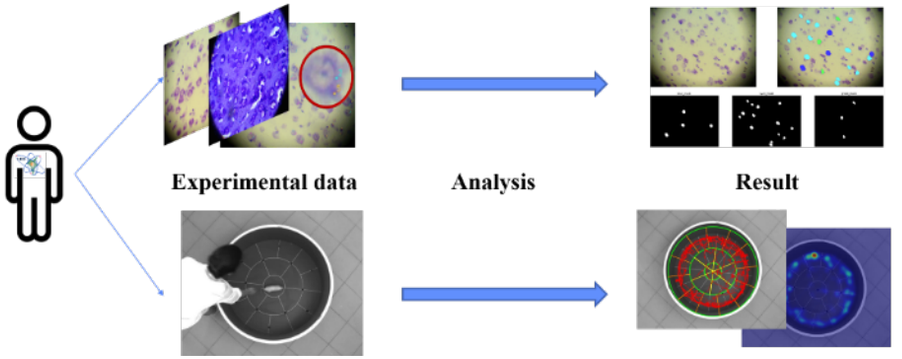
- The quantum controller (blue curve) is **almost 5 times faster in reaching the target value** than the closest controller on soft computing (green curve), while the PID-controller (red curve) does not reach the target value.
- The quantum controller demonstrates **low overshoot and accuracy in achieving the control goal** compared to other types of controllers.
- **Automatic control** based on the quantum controller **reduces nitrogen consumption by 53%.**

In the future, the system will be put into operation, and its regular operation will start.

BIOHLIT information system for radiobiological studies

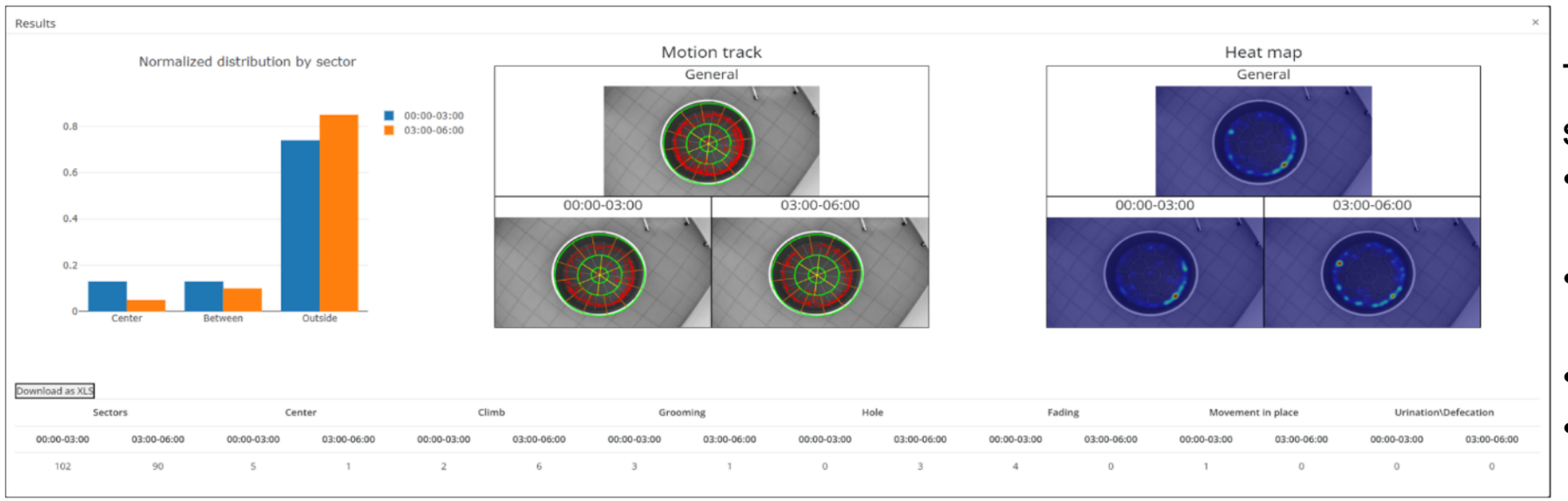
The information system allows one to store, quickly access and process data using a stack of neural network and classical algorithms of computer vision, providing a wide range of possibilities for automating routine tasks. It gives an increase in productivity, quality and speed of obtaining results.

Conceptual scheme of the service



Developed algorithms:

- ✓ algorithms for the automated marking of the field of experimental setups,
- ✓ algorithms for tracking the animal's position in experimental setups of different types,
- ✓ algorithms for evaluating the animal's behavioral patterns.



The obtained information is stored in different forms:

- visualized track of the animal's movement,
- video file with tracking the animal's position,
- heat map by sectors,
- file that stores all the information for subsequent statistical analysis.

6th International Workshop on Deep Learning in Computational Physics (DLCP-2022)

Machine Learning in Particle Astrophysics and High Energy Physics	• ML methods in particle astrophysics and HEP. • Fast event generators based on ML for modelling of physics phenomena. • Multi-messenger data analysis of experimental data. • Application ML for data analysis in LHC, NICA, TAIGA.
Modern Machine Learning Methods	• Convolutional neural networks. • Recurrent neural networks. • Graph neural networks. • Modern trends in machine learning.
Machine Learning in Natural Sciences	• Biology and bioinformatics. • Engineering sciences. • Climate prediction and Earth monitoring.
Machine Learning in Education	• Machine learning in High education. • Outreach knowledge in machine learning.

More than **130 scientists** (90 in person, over 40 remotely) from research centers of **India, Kazakhstan, Mongolia, Poland, Romania, Serbia, Slovakia, Turkey, Uzbekistan** took part in the workshop. **Russia** was represented by participants from 15 universities and research centers.

Service for planning and logging excursions at JINR https://jinrex.jinr.ru

MLIT, together with the UC, developed a service for planning and logging excursions at JINR.

Main functions

COORDINATE THE CONDUCT OF EXCURSIONS

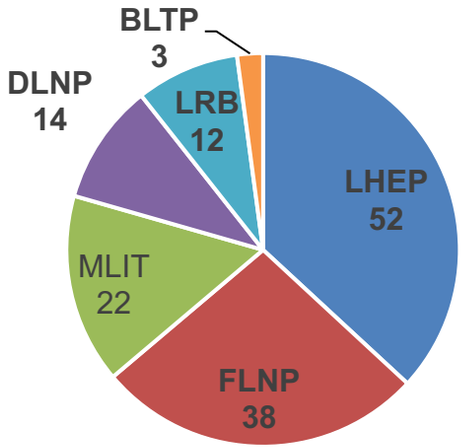
SAVE INFORMATION

MONITOR THE WORKLOAD OF THE VISIT POINTS

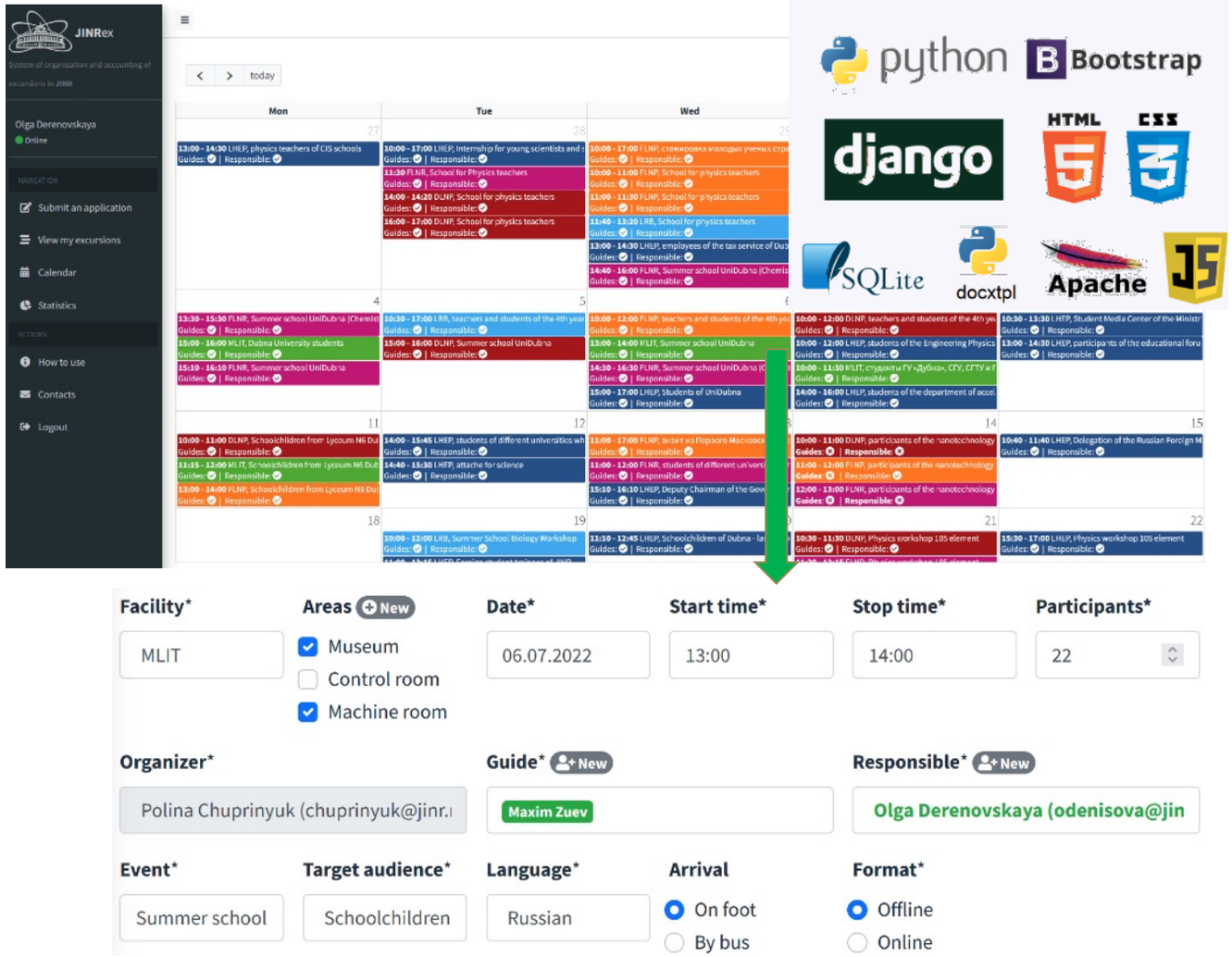
RECEIVE STATISTICS

The service provides summary information about all ongoing, planned and completed excursions and automatically sends email notifications about all important events.

Total number of excursions in April-August 2022



Used technologies

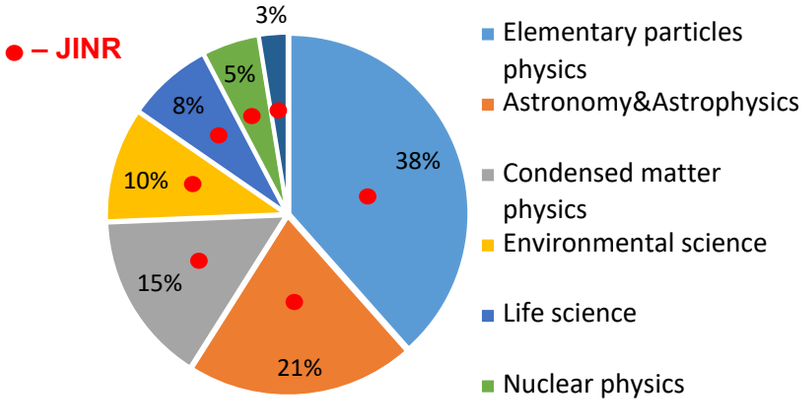


Задачи 2023: чем заканчиваем, чем прославляем и обогащаем, чем гордимся

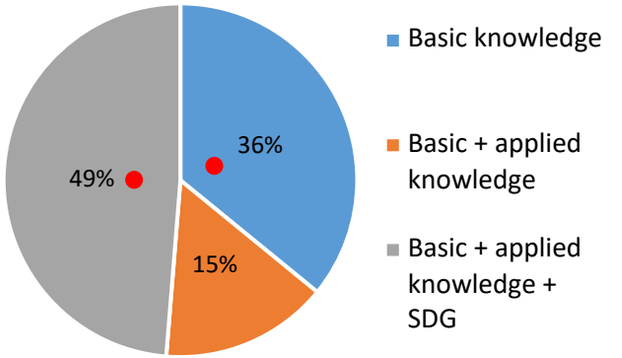
1. Приступаем к вводу в эксплуатацию проекта «Комплекс NICA». Начинаем международные экспериментальные исследования;
2. Фабрика сверхтяжелых элементов работает в ”крейсерском режиме». Введена в эксплуатацию в 2021 году. В десятки раз превышает возможности предыдущего комплекса ЛЯР и своих мировых конкурентов;
3. Глубоководный нейтринный телескоп на Байкале становится полноценным элементом глобальной сети масштабных нейтринных детекторов. Объем увеличен в 6 раз (с 2 до 12 кластеров), зарегистрировано >20 событий, связанных с нейтрино СВЭ.
4. IT-кластер -> ТОР1 в России и странах-участницах по объему хранилища данных, скорости передачи и эффективности обработки данных, Входит в 25 мирового ТОП-500;
5. ОИЯИ – один из ведущих мировых центров в области использования интенсивных нейтронных источников, входит в ТОП-5;
6. Международная программа исследований наук о жизни и инновационных исследований ОИЯИ полноценно заработала: новые базовые установки ЛРБ + каналы прикладных исследований NICA + новые базовые установки ЛНФ.
7. Современные и отвечающие современным вызовам тренды в кадровой политике (возраст, система оплаты труда), в цифровизации, в экологичности и безопасности деятельности ОИЯИ, значительная/кратная активизация

Мировые тренды в науке и ОИЯИ сегодня

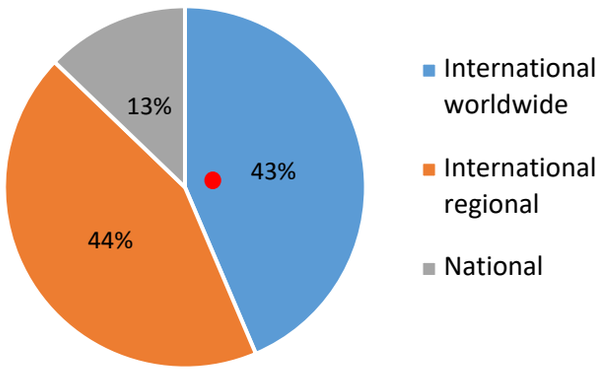
Distribution by fields of science



Distribution by mission



Distribution by international dimension



«Уставные» для ОИЯИ области науки занимают приоритетное положение в мировой научной повестке и развитии крупной исследовательской инфраструктуры.

Анализ показывает, что почти половина современных проектов в области фундаментальных наук имеет сопутствующие программы прикладных исследований, направленных на достижение целей устойчивого развития (ЦУР).

Мировое международное измерение, мультидисциплинарная научная программа и крупные инфраструктурные проекты ОИЯИ гармонично дополняют глобальную научную повестку и мировой ландшафт инфраструктуры меганауки, предполагая, наряду с основными целями в области фундаментальных исследований, также достижение ЦУР.

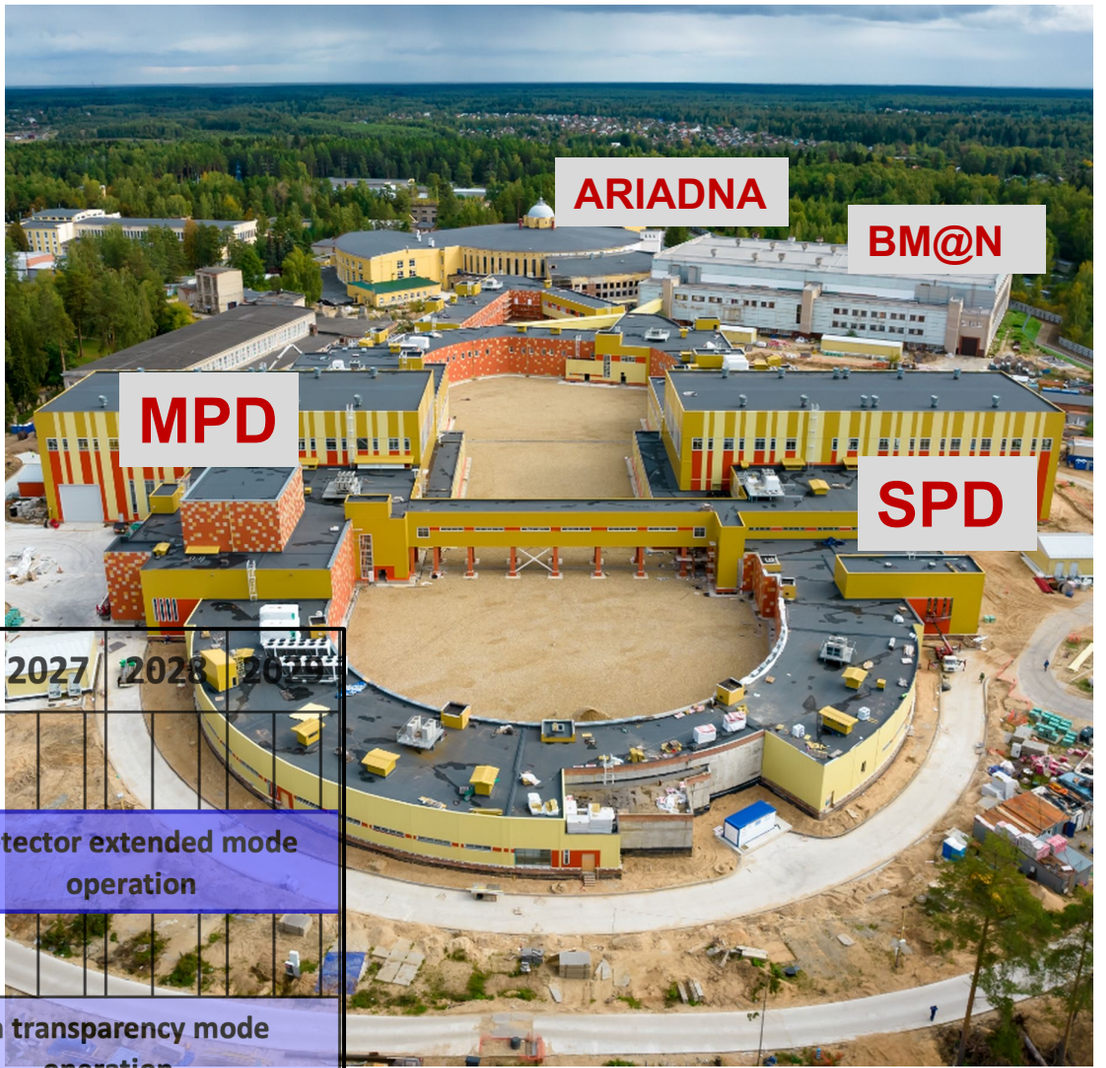
Крупные исследовательские инфраструктуры (КИИ):

- Большой адронный коллайдер (ЦЕРН)
- Европейский нейтронный источник (ESS)
- Центр исследований антипротонов и ионов (FAIR)
- LBNF-DUNE (нейтринный эксп-т)
- Будущий циклический коллайдер
- СНОЛАБ (подземный нейтринный комплекс)
- Европейский центр синхротронного излучения (ESRF)
- Нейтринный телескоп кубического километра (KM3NeT)
- Международный линейный коллайдер
- NICA (ионный коллайдер на базе нуклотрона)
- SCT (фабрика суперчарм-тау)
- Арктическое исследовательское судно "Амундсен»
- Чрезвычайно большой телескоп (ELT)
- Радиотелескоп SKA (ЮАР)

Около 40 КИИ по широкому спектру научных направлений, отвечающих критериям крупной исследовательской инфраструктуры (сложность, масштабность, уникальность, предназначение), как действующих, так и строящихся, а также некоторых планируемых – ICRI, GSF OECD, 2021

Relativistic Heavy Ion Physics and Study of nucleon structure. Near and Long-Term Future

- The timely completion of the NICA project, its commissioning and steady and efficient operation.
- Completion of the detectors: **BM@N**, **MPD** and **SPD** at NICA and successful data taking over the decades to come. JINR will make significant contribution to the basic configuration of the SPD detector.
- After several years of running of MPD, an Upgrade is foreseen, responding to an increase in luminosity of NICA. Adding detectors in the forward region as planned.
- Studies of possible future extension of NICA for acceleration of electrons, opening new physics potential via e-p and e-A collisions.

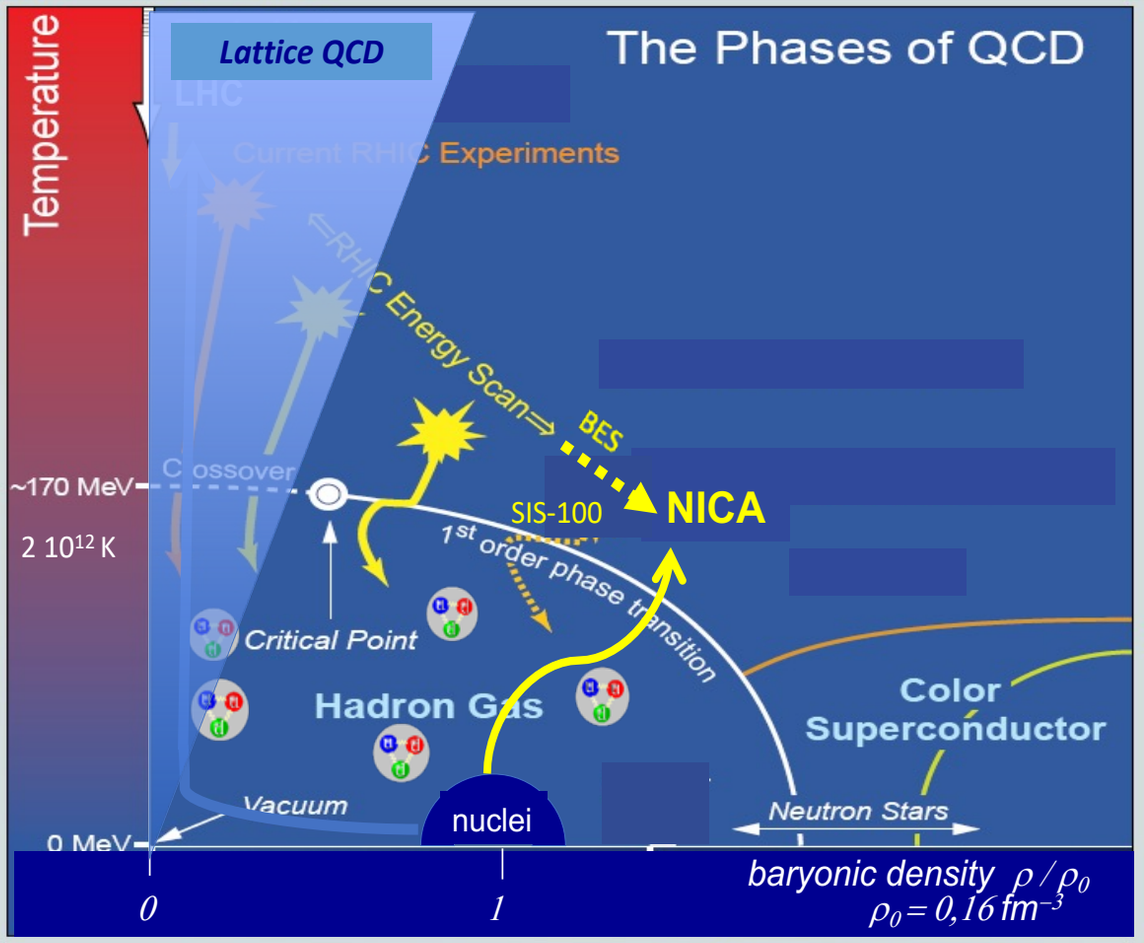


	2022	2023	2024	2025	2026	2027	2028	2029
NICA Collider commissioning		Commissioning runs						
MPD extended config. construction and opration			System design and production		Detector extended mode operation			
Consruction of NICA collider extended config.								
Prep. and start of polarized beam operation		SC-solenoids production and tests			Spin transparency mode operation			
SPD construction and commissioning	R & D, prototyping, testing			SPD systems production and assembly		SPD operation		
Nuclotron modernization	R & D, prototyping, testing			Magnets production, ring assembly		New Nuclotron operation		

BM@N & MPD

NICA

SPD



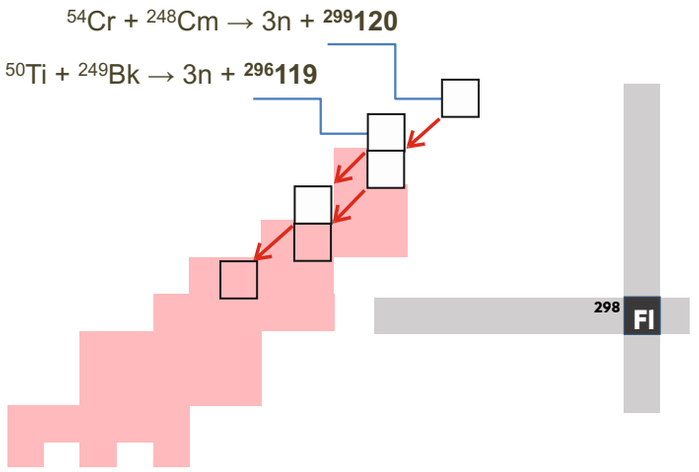
MPD covers this interesting region providing powerful combination of **large luminosity, collision energy and system size scan** (including isobars), large and consistent **acceptance,** full **centrality** range.

NICA is complementary to existing and planned world facilities (FAIR, SPS), and will be a natural and necessary continuation and significant expansion of studies at RHIC BES.

The SPD experiment is aimed at studying the properties of strong interactions in the nonperturbative region, at measuring the proton and deuteron spin structures, and at the development of a three-dimensional model of the nucleon. It is unique in its methodology, breadth of coverage and variety of tasks.

Experimental facility	SPD @NICA	RHIC	EIC	AFTER @LHC	SpinLHC
Scientific center	JINR	BNL	BNL	CERN	CERN
Operation mode	collider	collider	collider	fixed target	fixed target
Colliding particles & polarization	$p^{\uparrow}$-$p^{\uparrow}$ $d^{\uparrow}$-$d^{\uparrow}$ $p^{\uparrow}$-d, p-$d^{\uparrow}$	$p^{\uparrow}$-$p^{\uparrow}$	$e^{\uparrow}$-$p^{\uparrow}$, $d^{\uparrow}$, $^3He^{\uparrow}$	p-$p^{\uparrow}$,$d^{\uparrow}$	p-$p^{\uparrow}$
Center-of-mass energy $\sqrt{s_{NN}}$, GeV	$\leq$27 (p-p) $\leq$13.5 (d-d) $\leq$19 (p-d)	63, 200, 500	20-140 (ep)	115	115
Max. luminosity, 10^{32} cm^{-2} s^{-1}	~1 (p-p) ~0.1 (d-d)	2	1000	up to ~10 (p-p)	4.7
Physics run	>2025	running	>2030	>2025	>2025

Synthesis of new elements @ SHE Factory



TARGETS:

- Rosatom and ORNL (USA): *Isotopically enriched heavy actinide materials;*
- Radiochemical Lab of class 1

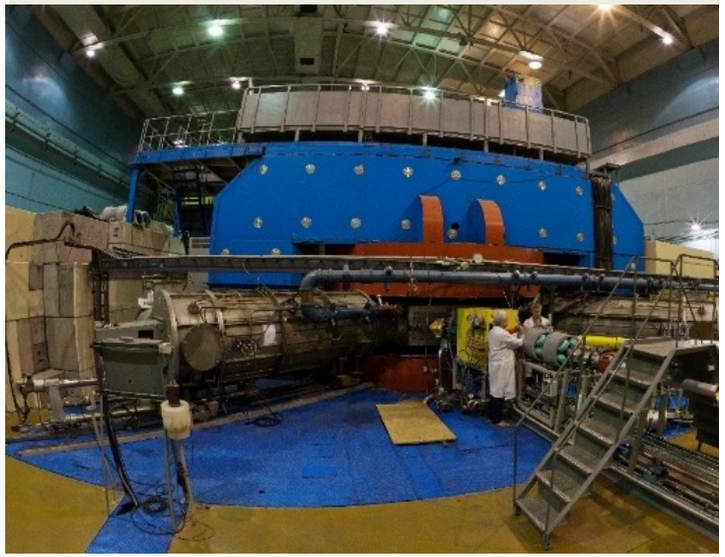
BEAMS:

- Production of high-intensity beams of ^{50}Ti, ^{54}Cr and others
- New ECR-28 GHz (2024)

Radioactive Ion-Beam research

Basic facility: U-400M

Ambitions: E up to 80AMeV, I x 2

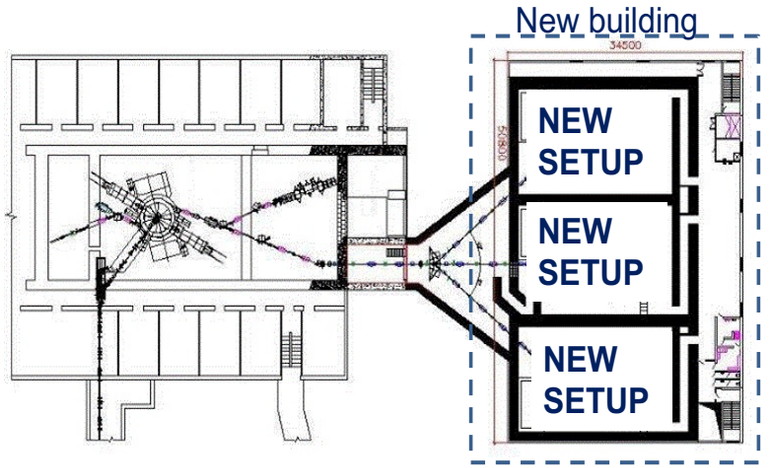


Operation from end of 2023

- Nucleon halo, neutron skin;
- Exotic decays: b-delayed, 2p,2n radioactivity;
- Soft excitation mode;
- New magic numbers;
- Spectroscopy of exotic nuclei;
- Cluster states;
- Reactions with RIBs;
- Astrophysical applications.

Nuclear reaction studies @ U-400R

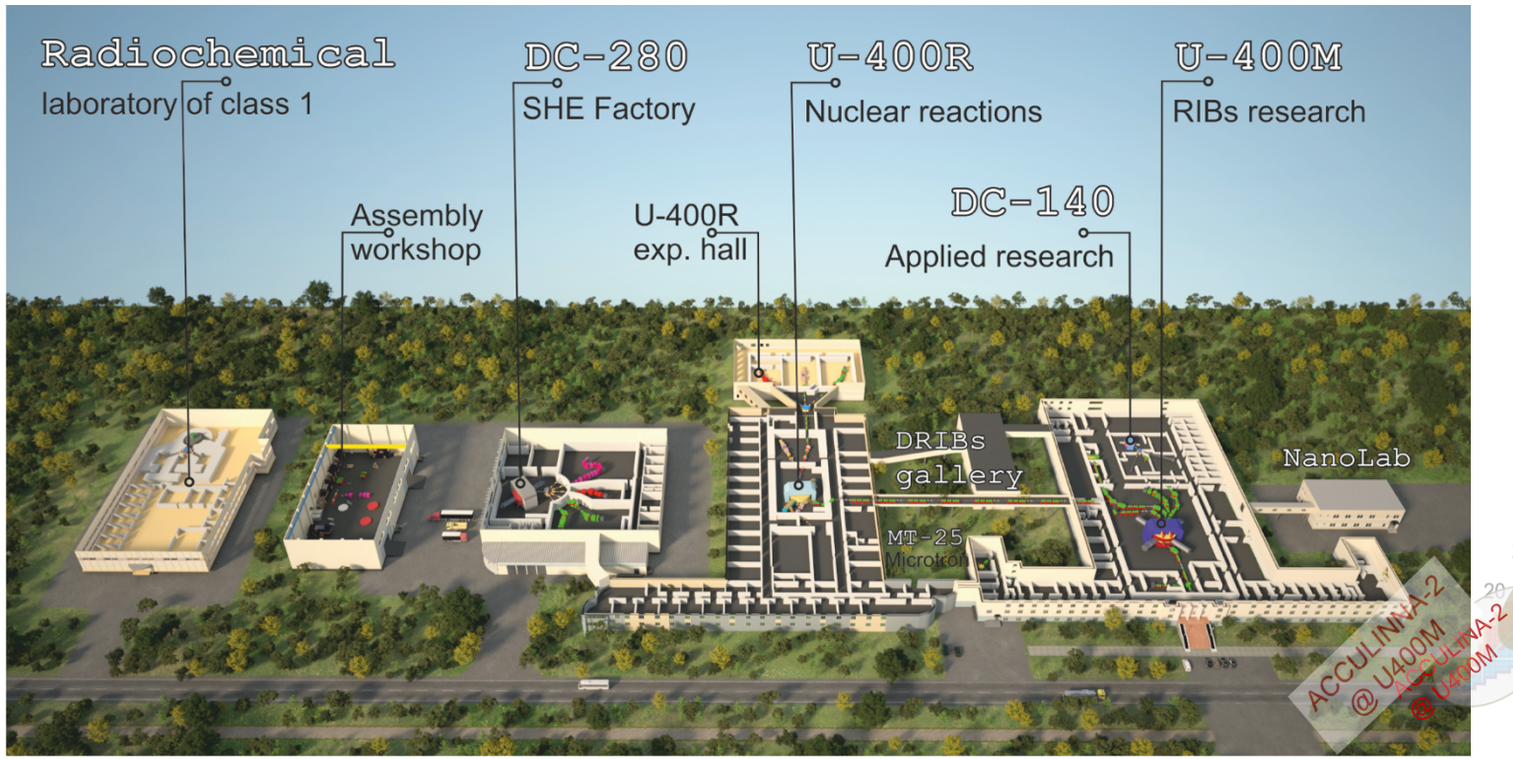
Ambitions: up to 2.6 mA (U-beam) 10^{10-11}, smooth energy variation



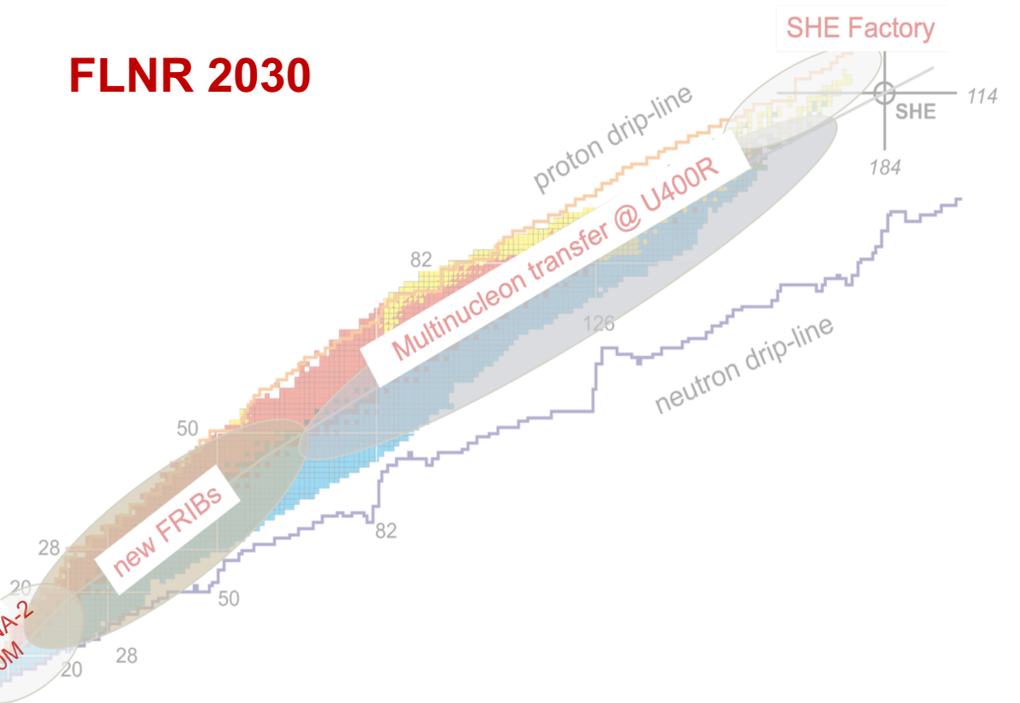
Upgrade in 2023-25. Operation from 2026

- **Multinucleon transfer reactions:** *Production of new isotopes of heavy,SH nuclei; Study of properties of new nuclei.*
- **Decay spectroscopy of heavy nuclei:** *actinides and light transactinides*
- **Study of fusion-fission and quasifission reactions leading to heaviest nuclei**
- **Low-energy and spontaneous fission of heaviest nuclei**
- **Study of nuclei at high excitation energies (several hundred of MeV)**

	2022	2023	2024	2025	2026	2027	2028	2029	2030
SHE Factory	Operation. Development of new setups								
U400M	Moderni-zation	Operation. Development of new detectors							
U400R	Operation	• New experimental hall constr. • Modernization of U400→U400R • Development of new setups			Operation. Development of new setups				
DC-140	Construction		Operation						
Class I Radio-Chemical Lab	Pre-design		Design		Construction			Operation	
New RIBs complex	Feasibility Studies, Pre-Design			International Evaluation, Design				Start of construction **(Funding is required)**	



FLNR 2030

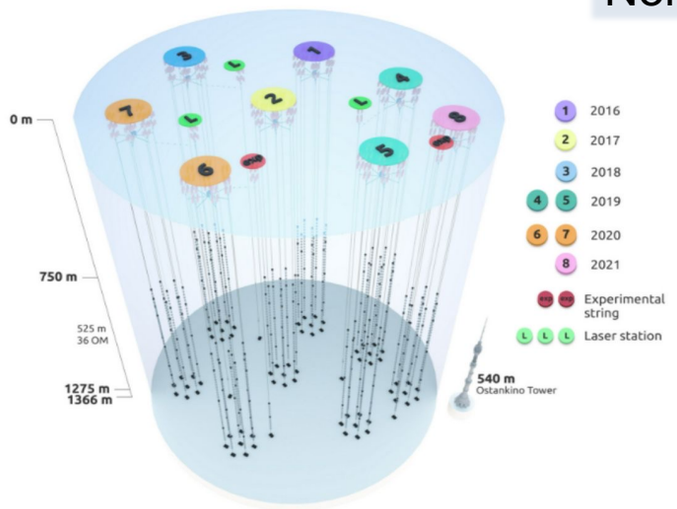


NEUTRINO AND ASTROPARTICLE PHYSICS

PROJECT BAIKAL-GVD

Baikal-GVD: Identification of astrophysical sources of ultra-high energy (exceeding tens of TeV) neutrinos. Actuality: their sources are still unknown. The identification of sources will help to elucidate mechanisms of galaxies creation and evolution.

Main advantage of Baikal-GVD: pure and t-stable water. Angular resolution of muon tracks 0.3-0.5 grad (IceCube: 0.5-1); angular resolution of shower direction 2-3 grad (IceCube: 15);
Northern detectors have better view to the Galaxy center.



Year	Number of clusters	Number of OMs
2016	1	288
2017	2	576
2018	3	864
2019	5	1440
2020	7	2016
2021	8	2304
2022	10	2880
2023	12	3456
2024	14	4032

Baikal-GVD: flagship experiment of JINR with a leading role in the collaboration. Gain new experience in the detector design, construction, deployment, maintenance, simulation and data analysis. Expected breakthrough discoveries.
More dense configuration, + light sensors, fiber vs Cu, smart data transmission, + radio-antennas → New Quality and Efficiency.

Global competence in 2030 horizon: Ice-Cube: 2025-2034 → 8km^3 (w RA 100 km3 => PeV); Km3NET: → few km^3; Baikal-GVD (Phase II) = new type of OM, trigger-less operation, ML&AI, → ~ 10 km^3 ? (CDR in 2024).

Neutrino, Astroparticle Physics

Neutrino oscillation experiments

- **Determination of CP-violating phase: DUNE (5σ significance in just two years)**
- **Determination of n mass ordering: NOvA (gaining new experience), JUNO**
- **Precise determination of elements of the lepton mixing matrix: JUNO (gaining further experience with reactor neutrino), DUNE**

Physical properties of neutrino

- **Determine if a neutrino is a Majorana particle: SuperNEMO, GERDA-LEGEND**
- **Coherent elastic n-nucleus scattering process at reactors: nuGEN (GEMMA)**
- **Sterile neutrino oscillation: DANSS**

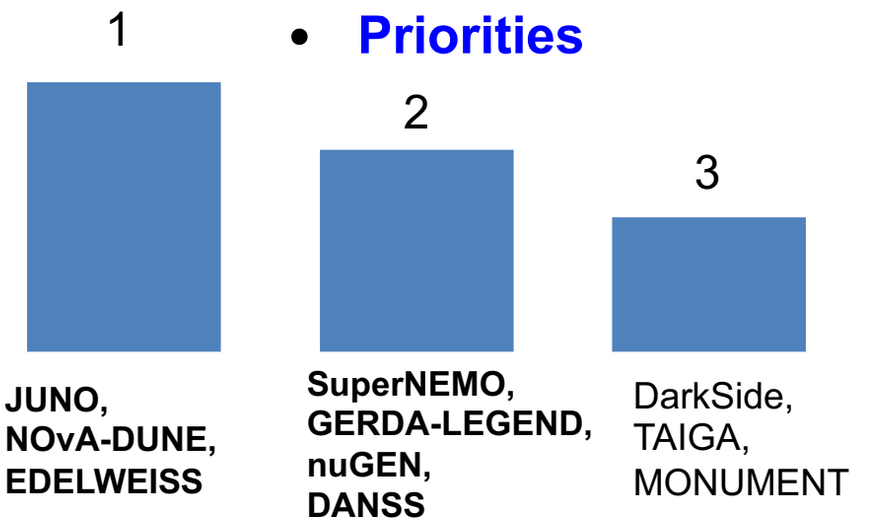
Motivation: involvement in possible major discovery, new instruments

Astroparticle Physics, Dark Matter discovery

- **Existence of the dark matter particles: DarkSide, EDELWEISS**
- **Sources of high-energy (exceeding tens of TeV) gammas: TAIGA**
- **Determination of nuclear matrix elements via muon capture: MONUMENT**

Motivation: involvement in possible major discovery, new instruments

- **Priorities**



Exp. Data Level&Scale | JINR recognition
Human Resources | Finance Resources

Condensed Matter Physics, Neutron Physics. Priority research in 2024-2030

THE IBR-2 FACILITY

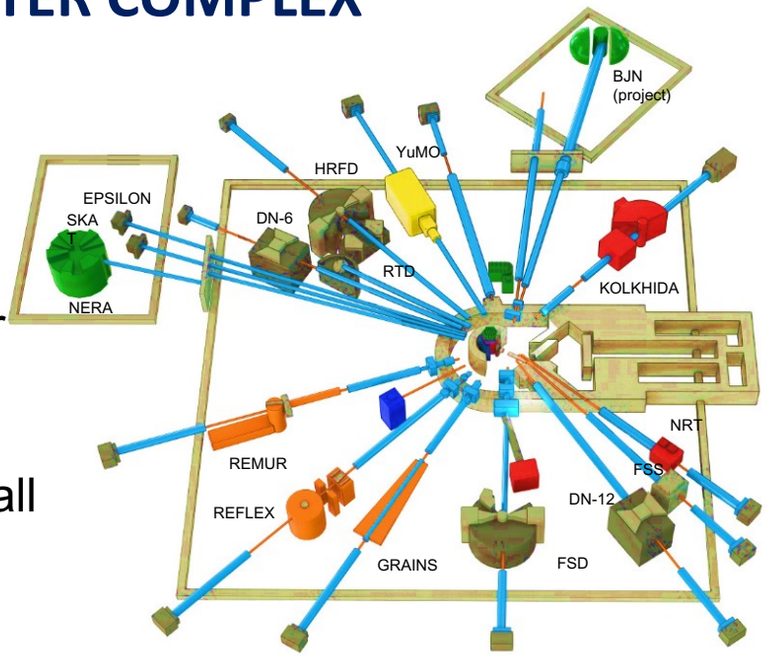
The service life of the core IBR-2 reactor is expected to end in 2032-35. **The possibility to extend the operation of the IBR-2 until 2040 is being studied.** To extend the reactor core campaign – new fuel (manufacture of FA with FR) around 2025.

Considering the present-day tendency, **after 2030 only five sources will be available in Europe**: ISIS (Didcot, UK), SINQ (PSI, Villige), FRM II (TU Munich), and two new sources: ESS (Lund, Sweden) and reactor PIK (NRC KI, Gatchina, Russia), both under construction with the start of operations planned for 2023-2024. Oak Ridge (STS SNS) –**is planned in 2037**.

JINR provides FS for new neutron source (**IBR-3** = "**NEPTUNE**"). The goal – is to have the **best** pulsed neutron source in the world by 2037: with brightness of 7*10^15 (for TN), and 9*10^14 (for CN)

SPECTROMETER COMPLEX

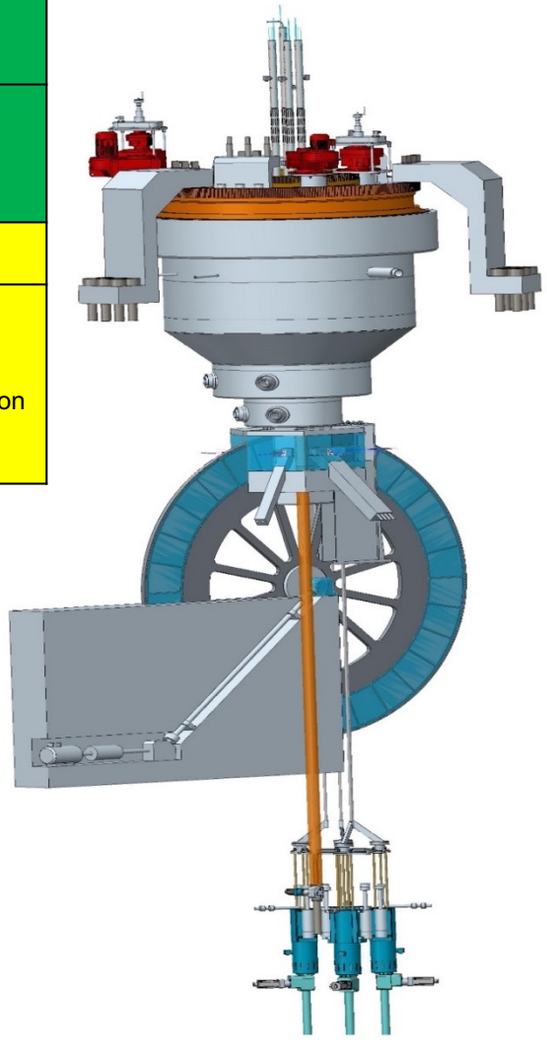
- Development of the basic configuration elements of the inverse geometry inelastic n-scattering spectrometer BJN.
- Completion of basic configuration of the small angle n-scattering and imaging spectrometer.



- Modernization and reconstruction of spectrometers HRFD, YuMO, RTD, DN-6, DN-12, FSD, NERA, REMUR, REFLEX, SKAT, EPSILON, FSS, NRT, focused on improvement of technical parameters and extension of research capabilities.
- Development of laboratory equipment for samples characterization and physical properties measurements.
- Support and modernization of the complex of cryogenic moderators. **New operating reliable UCN channel.**

FLNP LONG-TERM PLAN UP TO 2030

	2022	2023	2024	2025	2026	2027	2028	2029	2030
IREN	Operation. Development of new experimental setups.								
			Experimental hall modernization.						
EG-5	Operation.	Modernization.		Operation.					
TANGRA	Operation.			**Hall and lab modernization.**	Operation.				
UCN source	Pre-design.				Design.		Construction.		
New fast neutron source based on tandetron accelerator	Feasibility studies, Pre-design.					International Evaluation, Design			Start of construction



R&D of neptunium-nitride fuel of NEPTINE reactor (JSC VNIINM, 2022)

R & D for the development of fuel rods includes the following stages:

1) permit to use of nuclear materials, which is in federal ownership;
2) development of preliminary design specifications for neptunium nitride fuel;
3) development a complex of fuel characteristics' measurement methods;
4) development a technology of fuel fabrication for experimental fuel rods;
5) carry out of fuel rods researches before reactor irradiation;
6) reactor irradiation of fuel rods (with dose of 77 dpa)
7) post-irradiation researches of fuel rods in hot cells

JINR Life Science Program: Basic and Applied Research

Applied Research and Innovation Committee at NICA (NICA ARIC) – core of future SAC: F. Cucinotta (Univ. of Nevada, USA), M. Durante (GSI, Germany), T. Hei (Columbia Univ, USA), Rubén García Alía (RADNEXT Project, CERN), C. Trautmann (GSI, Germany), A. Paccagnella (Univ. of Padua, Italy), A. Pesce (ESA), Yu. Titarenko (ITEP KI, Russia), H. Sakurai (Nishina Center, RIKEN, Japan), A. Osipov (Burnasyan Center FMBA, Russia), F. Azaiez (iThemba LABS, South Africa).

Dzhelepov Laboratory of Nuclear Problems

- Study for p-therapy
- Study of damage suppressor of tardigrades
- Study of genetic modify's due to radiation dose
- Detectors and Tomography

Laboratory of Radiation Biology - Integrator

- Fundamental Radiobiology
- Radiation Neuroscience
- Clinical Radiobiology
- Mathematical Modeling
- Radiation Protection
- Astrobiology

Infrastructure for molecular, cellular and animal research

Veksler and Baldin Laboratory of HEP

- Heavy ion beamlines for radiobiology, beam therapy, animal research

Frank Laboratory of Neutron Physics

- Beamline for neutron capture therapy of cancer
- Structural biology
- Ecology

Mecheryakov Lab. of Information Technologies

- High performance computing
- System for biological data storage and processing
- Bioinformatics, Machine Learning

Flerov Laboratory of Nuclear Reactions

- Ion beams for cellular research
- Radionuclides synthesis for radiation medicine

Development of vivarium, animal imaging and tomography, super-resolution microscopy; Equipment for multi-OMICS research; Construction of radiochemical class III lab blocks; R&D on compact irradiators for cellular research.

THEORETICAL PHYSICS (BLTP)

Theory of Fundamental Interactions

Theory of Atomic Nucleus

Theory of Condensed Matter

Modern Mathematical Physics

Interlaboratory cooperation

VBLHEP Hot and dense nuclear matter in heavy-ion collisions

DLNP
Neutrino physics

MLIT
Lattice QCD calculations

FLNR
Superheavy and exotic nuclei

DLNP *Few-body systems, Exotic nuclei*

FLNP
Condensed Matter, New materials

FLNR
Nanoporous 2D membranes, Ion irradiation

MLIT Computational methods for nuclear physics and quantum chemistry

Research and educational project

DIAS-TH

"Dubna International Advanced School of Theoretical Physics"

Human strategy:

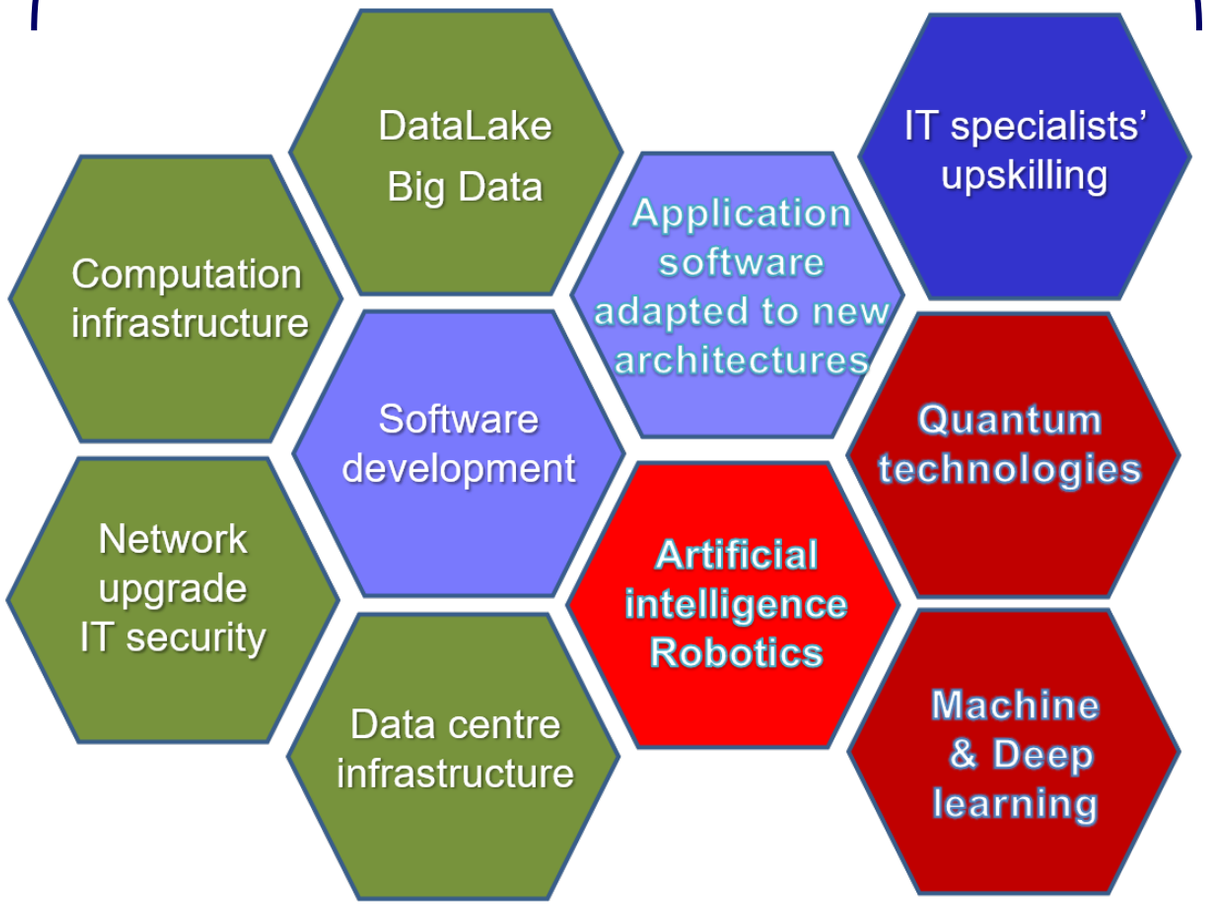
- ❑ Attraction of leading scientists
- ❑ Attraction of young researchers
- ❑ Stimulation of scientific activity

Scientific strategy:

- ❑ Extension of international collaboration
- ❑ Keeping up with current scientific trends
- ❑ Interplay of research and education

Strategy for Information Technology and Scientific Computing at JINR

Scientific IT ecosystem:



The coordinated development of interconnected IT technologies and computational methods

It will be **steady implementation/upgrades** of

- Networking (**Tb/s** range),
- Computing infrastructure within the Multifunctional Information & Computing Complex (MICC) and
- "Govorun" Supercomputer,
- Data center infrastructure,
- Data Lake & long-term storage

for all the experiments.

The **development of new data processing and analysis algorithms** based on

- ML/DL,
- artificial intelligence,
- Big Data
- Quantum technologies.

A variety of means will be used for IT specialists upskilling.

MICC as Resources Provider for NICA, LHC, HL LHC, Baikal-GVD, etc.

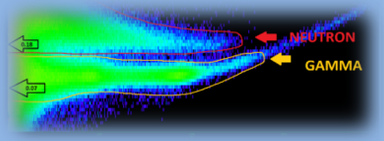
- The are three pillars in HEP experiments: accelerators – detectors – computing.
- To achieve physical results, HEP projects must proceed a huge amount of experimental data.
- Distributed heterogeneous computing must be used in future to support strategic research.
- The elaboration of new deep and machine learning algorithms for data processing and analysis will require support and development of a high-performance computing infrastructure.

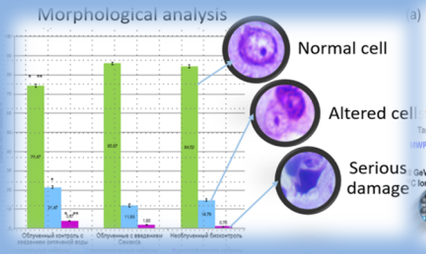
Needed computing for:

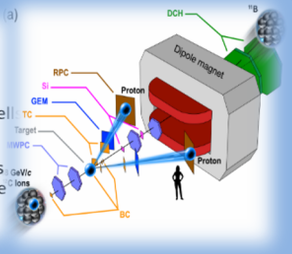
NICA Tier0 – Tier1 – number of Tier2

Baikal-GVD, NOvA, JUNO – **all types of resources**

LHC@HL-LHC – Tier1 for CMS,
Tier2 for ATLAS, ALICE





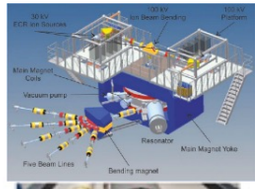


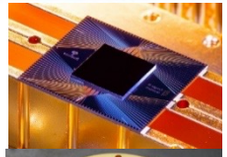
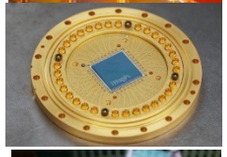
RESEARCH ENVIRONMENT FOR SOLVING RESOURCE-INTENSIVE TASKS OF JINR WITH "GOVORUN" SUPERCOMPUTER :

- Parallel computing
- ML/DL/AI tasks
- Quantum computing
- Tools for data analysis and visualization
- Calculations on application packages
- Web services for application programs
- Training courses

Quantum computing in the quantum robust control design



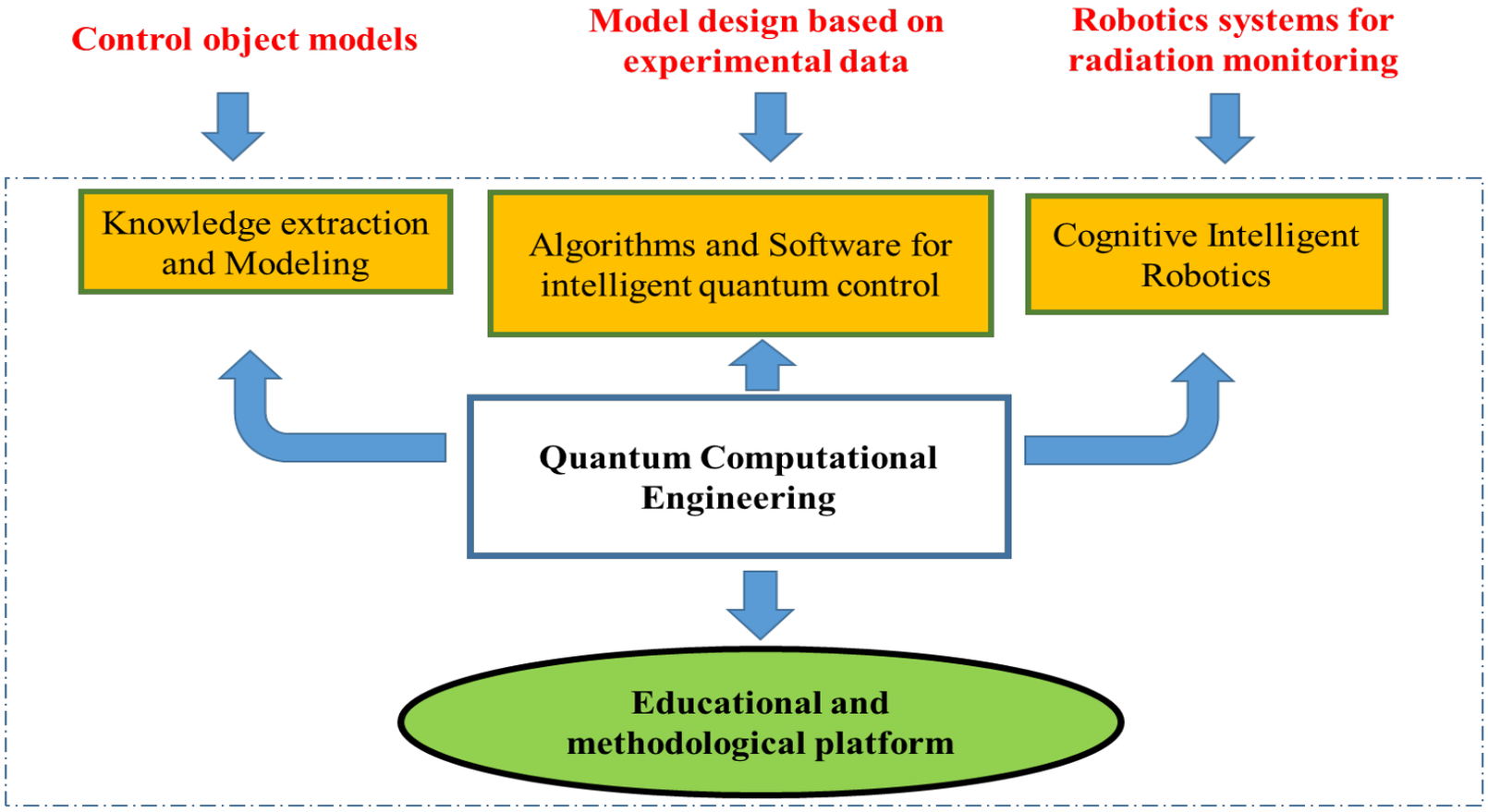



GOAL: Intelligent control of JINR physical experimental facilities
Robust control in unforeseen and unpredictable situations

USE@DO: Modern software technologies
Design of embedded intelligent controllers

PRODUCE: Intellectualization of innovative products
Communication of knowledge (master-slave system), adaptation and teaching in industrial complexes



Expected results:

- Applied library of quantum algorithms for JINR projects;
- Quantum simulators for modeling quantum algorithms on the “Govorun” supercomputer;
- Quantum control systems for NICA;
- Intelligent cognitive quantum robust controllers for intelligent control systems;

Participation in experimental collaborations worldwide

JINR intends to participate in advanced external experiments in the relativistic heavy-ion physics, particle physics and neutrino physics, provided that the potential for discoveries in these experiments is high, JINR researchers can play a leading role, and partner scientific organizations show mutual interest in strengthening cooperation.

Relativistic heavy ion physics

JINR scientists will continue the study of the properties of nuclear matter under extreme conditions, in the search for quark deconfinement and possible phase transitions within the framework of common research programmes in the STAR experiment at RHIC, BNL, in the NA61 experiment at the SPS accelerator (CERN), in the ALICE experiment at LHC (CERN), and in the CBM experiment at FAIR (GSI).

JINR's participation will depend on the progress in implementing the NICA project, as well as on the need to consolidate work at the JINR accelerator complex.

The nucleon spin structure and other polarization phenomena in nucleon–nucleon and nucleon–nucleus interactions

The SPD research programme will extend the ongoing research programmes of the COMPASS++/AMBER experiment (at SPS, CERN) on hadron structure and spectroscopy investigations with high-intensity muon and hadron beams, as well as with polarized proton beams at the STAR facility (RHIC), in which teams of VBLHEP and DLNP scientists of JINR will continue to take part during 2024–2028.

JINR's participation in these programmes will be coordinated with the JINR's efforts on the creation of the SPD detector and its research programme.

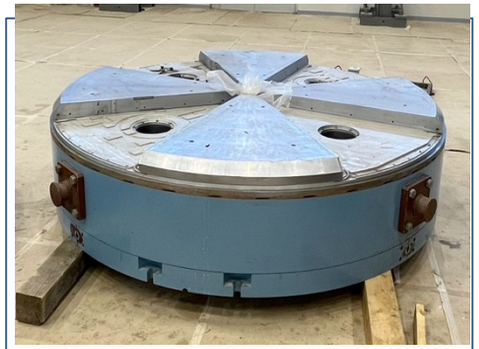
Elementary particle physics

The search for physical phenomena beyond the Standard Model will be continued in the CMS and ATLAS experiments at CERN’s LHC. JINR will take part in the second phase of detectors’ upgrade during the LHC shutdown periods in 2026–2028 and will continue analysis of data from the LHC. The JINR group will continue to participate in the NA64 experiment to search for weakly interacting particles of dark matter at the SPS accelerator at CERN. JINR will also take part in a search for charged lepton flavor violation in muon-to-electron conversion in nuclei in the μ2e (FNAL) and COMET (J-PARC) experiments.

INNOVATIONS: INTERNATIONAL CENTRE FOR NUCLEAR TECHNOLOGIES RESEARCH: STATUS AND PROGRESS

Development of technologies and methods in the field of nuclear and radiation medicine, radiation materials science, advanced training of specialists for JINR Member States for radiation biology, medical physics, material studies.

- **OMICS@LRB** and neuro-RB studies. Radiation neuroscience. Approaches to increase radiosensitivity: pharmaceuticals, transgene systems, targeted delivery (molecular vectors) and radionuclide;
- **ARIADNA.** Applied beams@NICA: radiobiological studies (400-800 MeV/n); radiation testing of semiconductor electronics (3; 150-350 MeV/n); nuclear physics @ 1-4.5 GeV/n. **Start in 2023**;
- **DC-140 cyclotron** for electronic component testing, radiation material science, track pore membrane research. **2021–2023**;
- **SC proton cyclotron (MSC-230)** for R&D in beam therapy: treatment planning; radiomodificators for γ– and p- therapy, flash-therapy, pencil beam (10 μA, >5 Grey/l @ 50 ms pulse). **2021–2024 (beam in 2023)**.
- **Radiochemical Laboratory Class-I** for production of radioisotopes (Ac^{225}, ^{99m}Tc), nuclear medicine R&D in photonuclear reactions @ 40MeV (e-beam, Rhodotron). **2022–2027.**

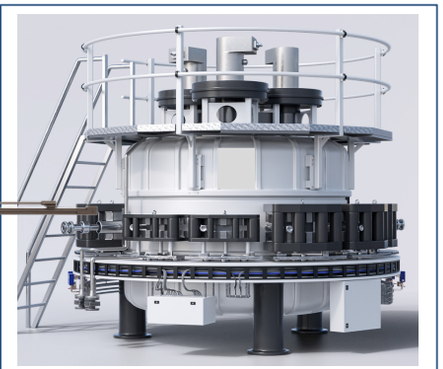


DC-140 (construction phase)

SOCHI beamline is ready (December 2021)

In progress

MSC-230 (general view)



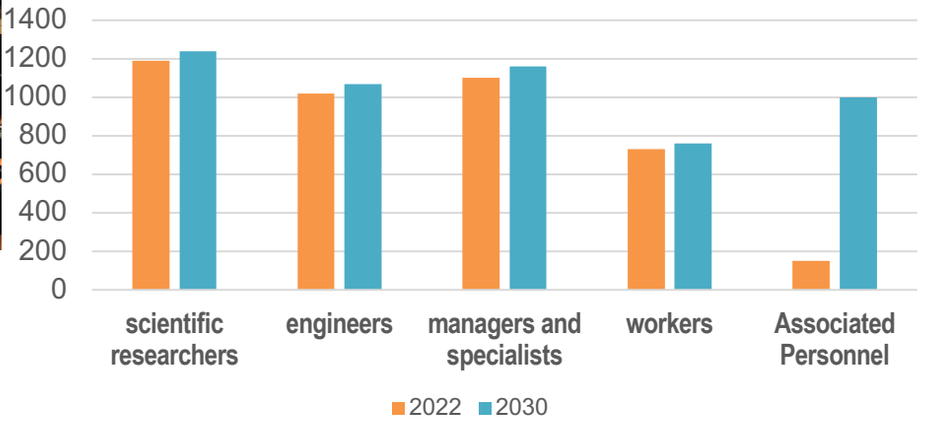
Radiochemical Lab Class-I

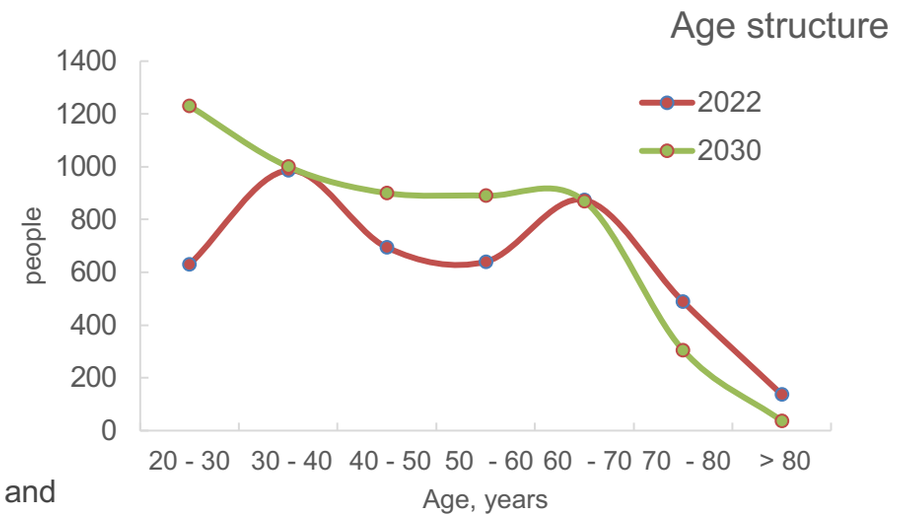
Directions of the Personnel Strategy 2024–2030

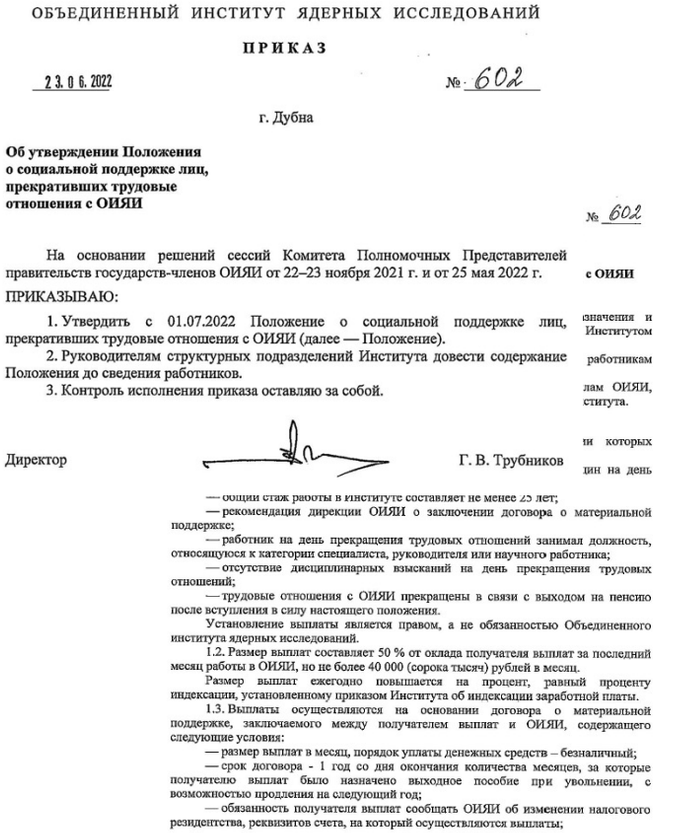
Moscow Regional Physics and Mathematics Lyceum named after Academician V. G. Kadyshevsky

Moscow State Univ. Branch in Dubna
Departments of Elementary Particle Physics and
Department of Fundamental Nuclear Interactions
and
Departments at **MIPT, MEPhI, SPbSU, Dubna University** and several others.

Personnel Structure of JINR
(total employees 4190 in 2022 and 5230 in 2030)







ОБЪЕДИНЕННЫЙ ИНСТИТУТ ЯДЕРНЫХ ИССЛЕДОВАНИЙ

ПРИКАЗ

23.06.2022 № 602

г. Дубна

Об утверждении Положения о социальной поддержке лиц, прекративших трудовые отношения с ОИЯИ

№ 602

На основании решений сессий Комитета Полномочных Представителей правительств государств-членов ОИЯИ от 22–23 ноября 2021 г. и от 25 мая 2022 г. с ОИЯИ

ПРИКАЗЫВАЮ:

1. Утвердить с 01.07.2022 Положение о социальной поддержке лиц, значения и прекративших трудовые отношения с ОИЯИ (далее — Положение). Институтом
2. Руководителям структурных подразделений Института довести содержание работникам Положения до сведения работников.
3. Контроль исполнения приказа оставляю за собой. лам ОИЯИ, ститута.

Директор Г. В. Трубников

ии которых

цин на день

— общий стаж работы в институте составляет не менее 25 лет;
— рекомендация дирекции ОИЯИ о заключении договора о материальной поддержке;
— работник на день прекращения трудовых отношений занимал должность, относящуюся к категории специалиста, руководителя или научного работника;
— отсутствие дисциплинарных взысканий на день прекращения трудовых отношений;
— трудовые отношения с ОИЯИ прекращены в связи с выходом на пенсию после вступления в силу настоящего положения.

Установление выплаты является правом, а не обязанностью Объединенного института ядерных исследований.

1.2. Размер выплат составляет 50 % от оклада получателя выплат за последний месяц работы в ОИЯИ, но не более 40 000 (сорока тысяч) рублей в месяц.

Размер выплат ежегодно повышается на процент, равный проценту индексации, установленному приказом Института об индексации заработной платы.

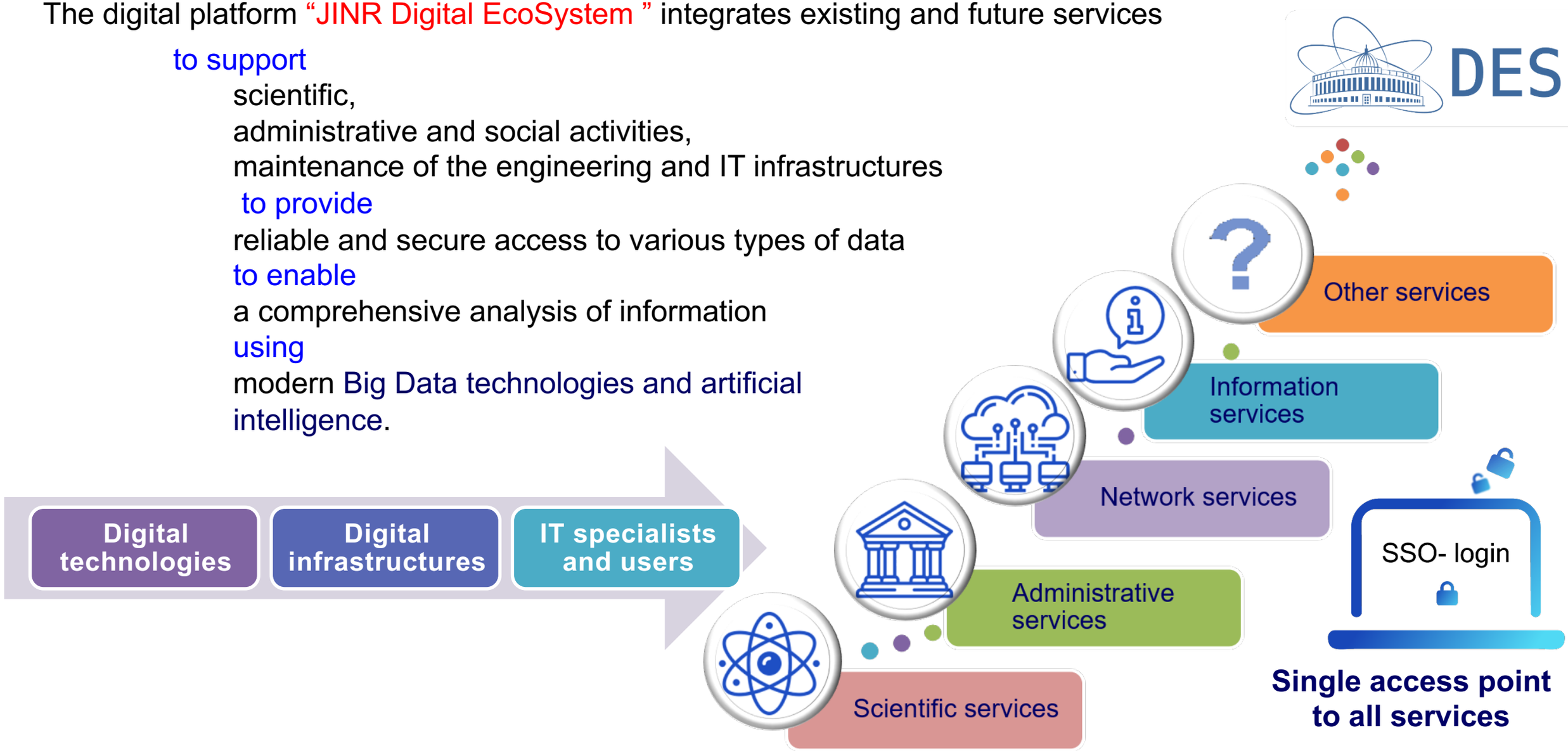
1.3. Выплаты осуществляются на основании договора о материальной поддержке, заключаемого между получателем выплат и ОИЯИ, содержащего следующие условия:
— размер выплат в месяц, порядок уплаты денежных средств – безналичный;
— срок договора - 1 год со дня окончания количества месяцев, за которые получателю выплат было назначено выходное пособие при увольнении, с возможностью продления на следующий год;
— обязанность получателя выплат сообщать ОИЯИ об изменении налогового резидентства, реквизитов счета, на который осуществляются выплаты;

- Обновление персонала (непрерывное образование)
- Возможность выхода на пенсию (договор социальной поддержки)
- Изменение возрастной структуры
- Значительное увеличение ассоциированного персонала.

JINR Digital EcoSystem (DES)

The digital platform “JINR Digital EcoSystem ” integrates existing and future services

to support
scientific,
administrative and social activities,
maintenance of the engineering and IT infrastructures
to provide
reliable and secure access to various types of data
to enable
a comprehensive analysis of information
using
modern Big Data technologies and artificial intelligence.

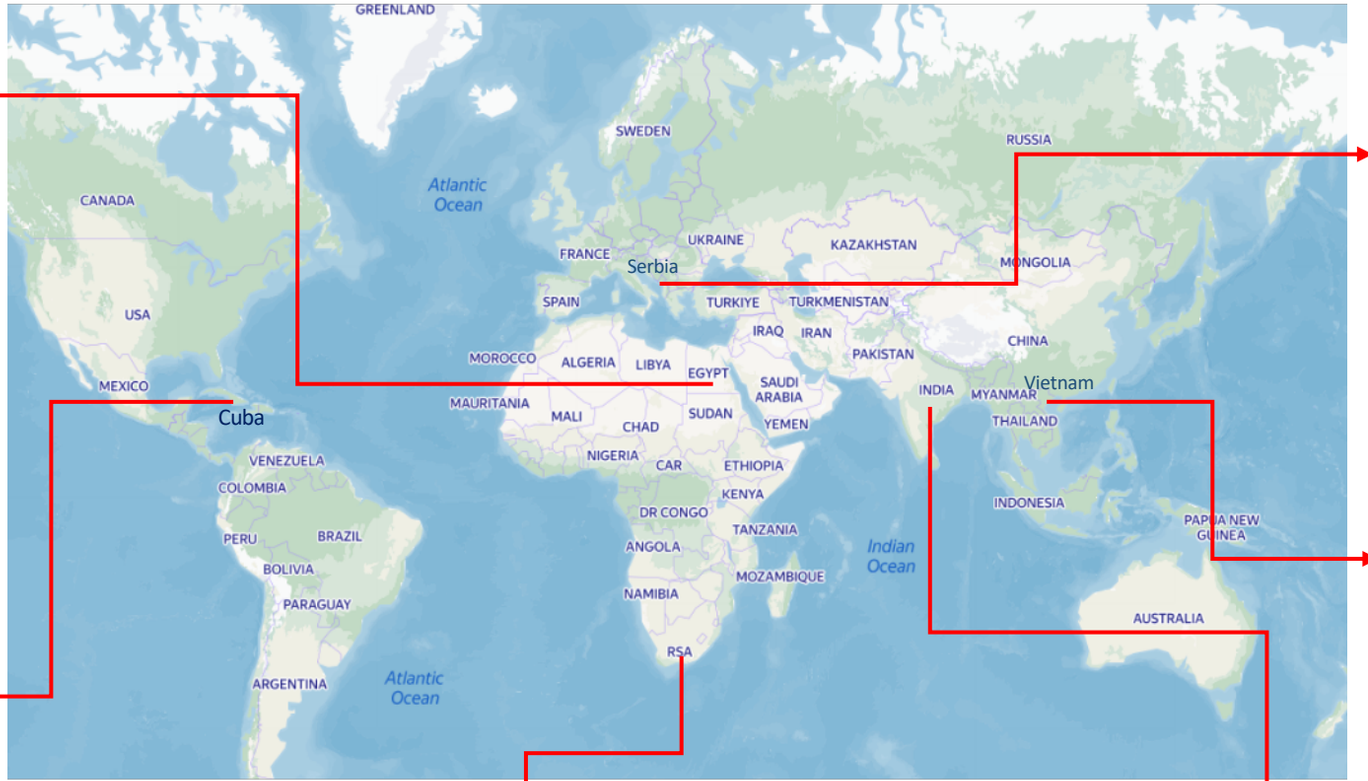


Региональный подход ОИЯИ к международному сотрудничеству

Northern Africa

JINR country
Egypt – member state
10 partner organizations

Hub organization
AAEA - MoU since 2016



Mediterian and Balcans

JINR countries
Bulgaria, Serbia

Partners in region
3 Israel
8 Turkey
5 Greece
5 Croatia, Montenegro, Slovenia

Latin American

JINR country
Cuba – member state
4 partner organizations

Partners in region
15 Brazil
6 Mexico
2 Argentina
2 Chile
1 Ecuador
1 Peru

East and South-East Asia

JINR country
Vietnam – member state
10 partner organizations

Partners in region
21 China
5 Thailand
1 Indonesia

South African

JINR country
South Africa – associated member
10 partner organizations

Partners in region
1 Botswana

South Asian

Partners in region
24 India
3 Pakistan
1 Bangladesh
1 Sri Lanka

Наиболее эффективным инструментом расширения контактов ОИЯИ является программа долгосрочных стажировок на конкурсной основе, с 60-х годов успешно работает как "Стипендиаты ОИЯИ» + Создание сети представительств ОИЯИ в региональных центрах.

7-YP (2024-2030):

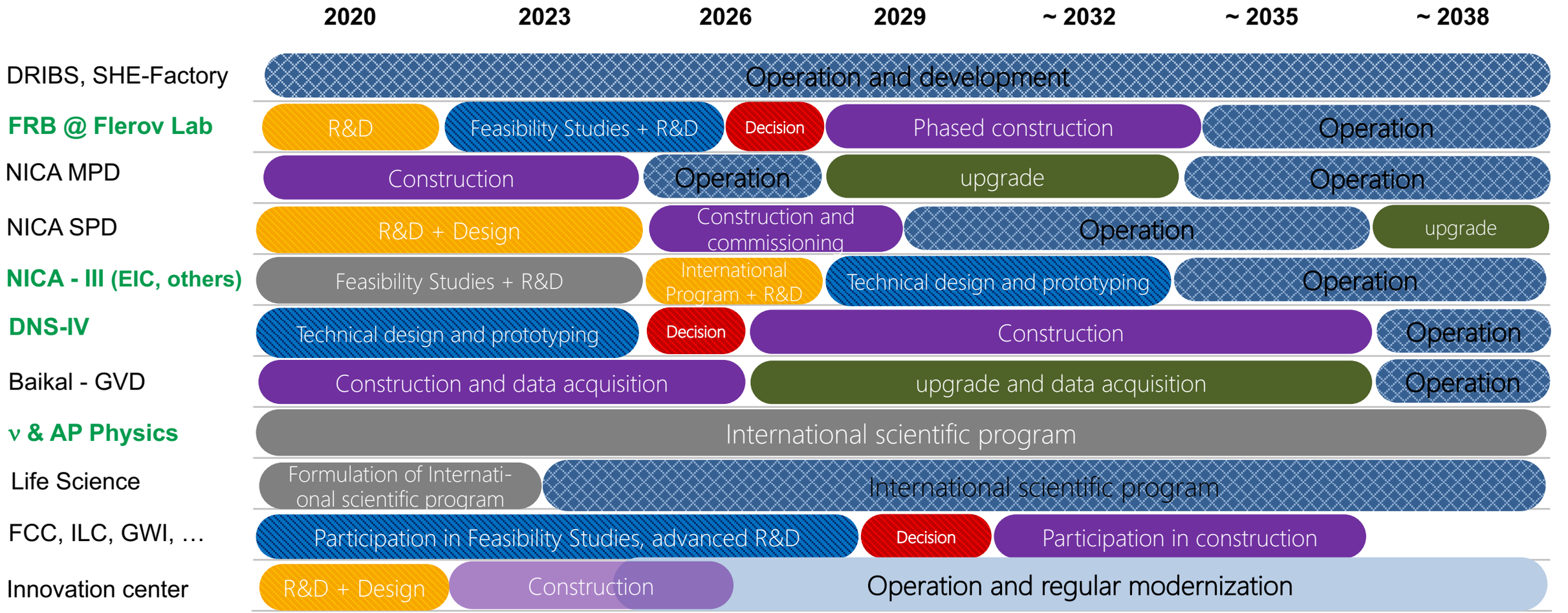
- Physics, Data acquisition and analysis, ”Harvesting”. Reliable, open, globally demanded Research (NICA, SHE, IBR2, νF, MICC, LS+IC)
- advanced R&D, Feasibility studies for new large-scale project @ JINR.

Research@Dubna: Topical Plan → Directions (Areas) → Projects → Activities. Basic Research Landscape and Priorities: where Dubna has recognized groundwork, and level/scale of tasks is/definitely will be world leading. Projects (approach «plan/schedule/results”) – are instruments.

Research @ Dubna: of great importance the Openness and the Institute's participation in experiments at world Research centers (CERN, FAIR/GSI, GANIL, BNL, DESY, INFN, IHEP, RIKEN, KEK etc), as well as in neutrino experiments and IT, where unique conditions for research are created. Key factors: JINR's participation should be recognizable and defined by the scientific significance/scale of the Physics data obtained, as well as on the role of scientists from JINR; The mutual benefit from exchange of new data, new scientific technologies and theoretical developments must be followed.

JINR DOSCIENCE@DUBNA

MATRIX OF JINR KEY PROJECTS



Thank you !

BEAM PHYSICS AND ACCELERATOR TECHNOLOGIES

Scientists and engineers of JINR are active participants of the projects of state-of-the-art international accelerator complexes: LHC, XFEL, FAIR, RHIC, GANIL, INFN centers, J-PARC, IMP CAS, HIAF, EIC, ILC, CLIC, FCC, etc. **We will focus on R&D in the following areas:**

– highly charged intense ion sources for generating heavy-ion beams with a charge state (Z > 40+);

– superconducting magnetic technologies: high-field magnets with fields up to 14–20 T, fast-cycling high-field magnets (B > 4 T, ramp > 4 T/s), high-current cables and windings (I_cr >30 kA);

– studies in the field of high-temperature superconductivity, development of Dubna superconducting cable technologies;

– efficient fast cooling systems for intense hadron beams (~ 10–100 ms);

– superconducting resonators (RFQ and DTL) and cryomodules of RF structures for accelerating intense proton and ion beams, including those operating in the quasi-continuous mode at low initial particle velocities;

– research in the field of colliding beam accelerators: final optical structures, collision effects, focusing elements also based on radiation-resistant focusing on permanent magnets;

– issues of implementation of future colliders (FCC, ILC, CpeC, etc.);

– development of RF power systems based on solid-state power amplifiers;

– technologies of fast cycling synchrotrons for acceleration and accumulation of intense heavy-ion beams;

– R&D on beam therapy (flash, pencil beam, light ions, neutrons);

– deep machine learning for operation optimization and synchronization of systems of large accelerator complexes;

– development of modeling methods (including using artificial intelligence methods) of beam dynamics with the “real” accelerating and focusing electromagnetic fields in accelerator structures and in-flight beam parameters (emittance, intensity, charge composition, etc.).